



CAEPR Working Paper
#2007-023

The Macroeconomics of Health Savings Accounts

Juergen Jung
Indiana University Bloomington

Chung Tran
Indiana University Bloomington

Original: October 25, 2007

Updated: April 11, 2008

This paper can be downloaded without charge from the Social Science Research Network electronic library at: <http://ssrn.com/abstract=1024556>.

The Center for Applied Economics and Policy Research resides in the Department of Economics at Indiana University Bloomington. CAEPR can be found on the Internet at: <http://www.indiana.edu/~caepr>. CAEPR can be reached via email at caepr@indiana.edu or via phone at 812-855-4050.

©2008 by Juergen Jung and Chung Tran. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.

The Macroeconomics of Health Savings Accounts*

Juergen Jung[†] and Chung Tran[‡]
Indiana University - Bloomington

27th March 2008

Abstract

We analyze whether a consumer driven health care plan like the newly established Health Savings Accounts (HSAs) can reduce health care expenditures in the United States and increase the fraction of the population with health insurance. We use an overlapping generations model with health uncertainty and endogenous health care spending. Agents can choose between a low deductible- and a high deductible health insurance. If agents choose to purchase the high deductible health insurance, they are allowed to contribute tax free to an HSA. We examine the steady state effects of introducing HSAs into a system with private health insurance for young agents and Medicare for old agents. Since the model is a general equilibrium model, we fully account for feedback effects from both, factor markets and insurance markets. Our results from numerical simulations indicate that the success of HSAs depends critically on the productivity of health and the annual contribution limit to HSAs. In some experiments we found that HSAs can decrease total health expenditures by up to 3% of GDP but can also increase the number of uninsured individuals by almost 5%. We also address possible extensions of the HSA reform that include the eligibility to pay health insurance premiums with HSA funds, the full privatization of Medicaid via HSAs, and Medicare for workers.

JEL: H51, I18, I38

Keywords: Health Savings Accounts, Consumer Driven Health Care Plans, Health Insurance, Privatization of Health Care, General Equilibrium Health Uncertainty Model, Numerical Simulation of Health Care Reform

*We would like to thank Gerhard Glomm, Kim Huynh, Michael Kaganovich, and Rusty Tchernis for many helpful discussions. In addition, we would like to thank Alejandro Rodriguez Arana, Morris Davis, Selahattin Imrohoroglu, Morton Ravn, Elyce Rotella, Willard Witte, Yibo Zhang, and participants at the Jordan River Conference 2007, the Conference on Health Public Insurance in the Americas: Towards Universal Coverage, and The Second Annual Economic Graduate Student Conference at the Washington University in St. Louis 2007 for helpful comments. We acknowledge the use of the Teragrid Supercomputer “Big Red” at Indiana University, Bloomington.

[†]Corresponding author: Juergen Jung, Indiana University - Bloomington, Indiana, 47405, U.S.A.
Tel.: 1 (812) 345-9182, *E-mail*: juejung@indiana.edu

[‡]Indiana University - Bloomington, Indiana, 47405, U.S.A. *E-mail*: chtran@indiana.edu

1 Introduction

In 2003 about 250 million Americans became eligible to save tax free for their health care expenses in special Health Savings Accounts (HSAs) via the Medicare Prescription Drug, Improvement, and Modernization Act. HSAs were introduced with two main goals in mind. The first goal was to control the rise in health expenditures, and the second goal was to increase the number of Americans with health insurance.

Can HSAs deliver on these goals? Evidence is sparse, and the discussion has become increasingly polemic. Proponents of HSAs hail consumer driven health care plans as the panacea to the health care problem in the United States (Goodman (2004)¹), whereas opponents discredit the idea as “more tax cuts for the rich” (Burman and Blumberg (2003)).²

Since data is sparse, research on HSAs has focused on micro-simulations and partial equilibrium models (e.g. Keeler, Malkin, Goldman and Buchanan (1996), Ozanna (1996), Zabinski, Selden, Moeller and Banthin (1999), Pauly and Herring (2000), and Cardon and Showalter (2007)) and concentrated on the moral hazard and adverse selection aspects of the insurance component of HSAs.³ This literature is inconclusive as to whether HSAs decrease total health expenditures. Estimates range from decreases in total health expenditures of 8% to increases in total health expenditures of 1%. One of the first empirical studies on HSAs by the Government Accountability Office (GAO (2006)) finds that higher income households are more likely to have HSAs. The same study did not find a pattern on which age groups are more likely to have HSAs. Another empirical study by Greene, Hibbard, Dixon and Tusler (2006) confirms that healthier workers with higher educational attainment are more likely to buy into high deductible health insurances.

While there is an emerging empirical literature on the effects of HSAs, we find a paucity of economic models that address the macroeconomic implications of reforming the U.S. health care system with HSAs. Since at this point there is no reliable data on HSAs available, substantial insight can be gained from a carefully designed simulation that is model based, allows for policy predictions, and is supported by economic theory. In order for such a model to be credible it must include an adequate representation of intertemporal consumption choice and major institutional features of HSAs. In addition, such a model has to go beyond partial equilibrium analysis because HSAs have the potential to significantly change the savings portfolio of U.S. households in the long run. This will create large general equilibrium effects via factor markets and insurance markets, especially since health is a major component of human capital (e.g. Grossman (1972) and Schultz (2002)). It is important to include these feedback channels when analyzing the effects of HSAs on the entire economy.

In this paper, we analyze HSAs from a macroeconomic perspective and focus on whether the introduction of HSAs can reduce aggregate health expenditures and increase the number of insured individuals. To our knowledge, this is the first model that captures the general equilibrium effects of HSAs in a framework with endogenous health choice and health uncertainty.⁴

¹Compare also the publications of the National Center for Policy Analysis (NCPA) at <http://www.ncpa.org/pub/ba/ba464/>

²See also the more critical views in Hsiao (1995), Hsiao (2001) and Barr (2001).

³Four countries have implemented HSAs so far – Singapore, South Africa, China (experimental stage), and the United States. We present a brief summary of the literature on HSAs in these countries in Appendix B, which is available on the authors’ website at: http://mypage.iu.edu/~juejung/Papers/hsa_appendixB.pdf

⁴Macroeconomic frameworks that model tax sheltered savings accounts or endogenous health capital formation, but not both, include Imrohoroglu, Imrohoroglu and Joines (1998) who address the savings effects of individual retirement accounts. Jeske and Kitao (2005) provide a mechanism to model the institutional details of choosing between private health insurance bought in the group market or the individual market. Suen (2006) uses a variant of a Grossman (1972) model with endogenous expenditure on medical treatments that increase the health capital of an agent. He investigates how growth in health expenditures is driven by technological factors and health accumulation. Hubbard, Skinner and Zeldes (1995) investigate the role of targeted social insurance on the asset distribution in the U.S. Palumbo (1999), who estimates a health uncertainty model using U.S. data. Models

We use an overlapping generations model with health uncertainty that is similar to Jeske and Kitao (2005) and calibrate it to match U.S. data. In contrast to Jeske and Kitao (2005), medical expenses are endogenous in our model and are used to build up health capital. Health capital is a key component into the formation of human capital which enters the production process. In addition, we model the institutional setup of HSAs together with a standard savings technology. Agents are borrowing constrained in the sense that they are not allowed to hold negative net asset positions.⁵ In our experiment we introduce HSAs into an economy that is calibrated to U.S. data before the introduction of HSAs. We then study the macroeconomic effects caused by HSAs. This framework not only allows us to make statements about endogenous health plan choices, the formation of health insurance premiums, and aggregate spending on health but also on aggregate effects of physical capital formation, human capital formation, and the wealth distribution. The model explicitly accounts for general equilibrium effects from price changes in factor markets and insurance markets on savings and health care expenditures. Micro simulations and partial equilibrium models do not account for these effects.

In numerical simulations we find that HSAs can indeed decrease total health expenditures in the economy by up to 3%. However, at the same time the number of uninsured individuals can increase by up to 5%. The decrease in aggregate health expenditures is a direct result of the prevalence of high deductible insurances after HSAs are introduced. High deductible insurances increase the relative price of health services, so that households shift their spending from health care to consumption goods. Lower health care spending decreases health capital in the economy. Since health capital enters the formation of human capital, lowering aggregate health expenditures will have a negative effect on output. This is the first general equilibrium channel that feeds back into the household decision problem. In addition, HSAs stimulate the accumulation of physical capital because large portions of savings become tax free. However, since larger savings in physical capital are not enough to compensate for the loss in productive human capital, aggregate output declines. This decreases household income and increases the number of people without health insurance. We conduct sensitivity analysis and find that the parameter determining whether health capital is also an investment good is key in establishing whether HSAs increase the number of insured workers (extensive margin) and decrease total health expenditures (intensive margin). We also find that as health capital becomes more of a pure consumption good, the differences between partial equilibrium results and general equilibrium results become substantial. Partial equilibrium results then grossly overstate aggregate health levels in the economy. In addition, we show that the annual contribution limit to HSAs plays a key role in determining the fraction of the insured population. With a high enough annual contribution limit, HSAs will decrease total health expenditures and increase the number of insured workers. The downside of this is lost government revenue and a likely increase in the fiscal deficit. Given a certain productivity of health the model allows us to identify the exact range of the annual contribution limit that allows HSAs to perform on both goals, decrease total health expenditures and increase the number of insured people.

In the next section, we describe the institutional details of HSAs and discuss the goals of HSAs. In section 3 we introduce our model and define the equilibrium. We address the calibration of the benchmark economy without HSAs in section 4. In section 5, we compare the benchmark economy to U.S. data. Policy experiments are described in section 6. In an extension, we also address current health care reform proposals. First, we address the Affordability in the

addressing the effects of Medicare on labor supply, retirement decisions, and moral hazard include Rust and Phelan (1997), Gilleskie (1998), French and Jones (2004), Khwaja (2002), and Khwaja (2006).

⁵Without a borrowing constraint households would make the maximum allowable contribution to their HSAs if interest rates were fully tax deductible (this was possible until 1986). Borrowing constraints can either be modeled as a wedge between the interest rates on borrowing and lending, or a threshold on the minimum asset position. See also Imrohoroglu, Imrohoroglu and Joines (1998) for a further discussion.

Individual Market Act (S.2554) which proposes to extend eligible health expenses of HSAs to include health insurance premiums. Finally, we run policy experiments that simulate both, the total privatization of Medicare in an economy with HSAs and the expansion of Medicare to the population younger than 65. We conclude our findings in section 7. Appendix A contains all tables and figures. Appendix B contains a brief history of HSAs in the U.S. and describes the experience of Singapore, China, and South Africa with HSAs. Furthermore, Appendix B discusses the solution algorithm and contains a section explaining the estimation technique for health shock transition probabilities.⁶

2 Institutional Details of HSAs

An HSA is similar to a Flexible Spending Account (FSA), Health Reimbursement Account (HRA), Individual Retirement Account (IRA), or 401(k) in the sense that funds are deposited into the account out of pretax income and interest accumulates tax free. HSAs can only be established in conjunction with a qualified High Deductible Health Plan (HDHP). A qualified HDHP must have at least a \$1,100 deductible for an individual (\$2,200 for a family). Any individual who is covered by an HDHP, not covered by other health insurance, not enrolled in Medicare, and not claimed as a dependent on someone else's tax return is eligible for an HSA. Contributions can be made by either the employer, the employee, or both, but the HSA is owned by the employee. The maximum annual contribution is \$2,850 for an individual (\$5,650 for a family). Distribution of the funds is tax-free if taken for "qualified medical expenses" (which now includes over-the-counter drugs). Unused funds are rolled over at the end of the year. Currently, funds cannot be used tax-free to pay premiums of health insurance with some exceptions. Funds withdrawn for non-medical purposes are subject to a 10% penalty tax (except in cases of death, disability, or Medicare eligibility) and regular income tax. After the account holder turns 65, the 10% tax penalty no longer applies. In case of death the HSA can be transferred tax-free to a spouse.⁷

In general, Health Savings Accounts (HSAs) have four objectives: *(i)* reduce health care costs, *(ii)* lower premiums and thereby increase the number of insured individuals, *(iii)* change the structure of health care into a fully funded system where high savings rates increase growth rates, and *(iv)* put the patient into the center of the health care decision making process. With our model we are able to address the first two objectives. We do not model population aging but our model does explicitly take the savings effect of HSAs into account. We do not model the ex-post moral hazard problem embedded in the last objective.

The high deductible health care plans are said to encourage individuals to be more prudent consumers of health care, because they will be responsible for the cost of health care below the deductible. They are therefore more likely to limit health care use to necessary, cost-effective services.⁸ In addition, the consumer is expected to "shop" for the best offer available in the market (e.g. buy generic drugs instead of brand names, compare prices for certain health procedures, etc.), as stated in Goodman (2004).

Whether or not HSAs reduce costs is controversial. Nahata, Ostaszewski and Sahoo (2005) and Buntin, Damberg, Haviland, Kapur, Lurie, McDevitt and Marquis (2006) conclude that HSAs may be able to reduce some of the distortions introduced by traditional health insurance and have a moderate effect on preventing cost increases. Ozanna (1996) finds a decrease between 2% to 8% in health spending after the introduction of HSAs, whereas Keeler et al. (1996) find

⁶ Appendix B is available on the authors' website at: http://mypage.iu.edu/~juejung/Papers/hsa_appendixB.pdf

⁷ Appendix B contains all institutional details of HSAs and the important differences to the alternative forms of tax sheltered savings.

⁸ See also Manning, Newhouse, Duan, Keeler, Leibowitz and Marquis (1987) on how cost sharing affects the demand for medical services. The RAND experiment shows that catastrophic insurance plans with copayments can reduce health expenditures significantly.

those ranges to be between a 1% increase to a 2% decrease. Heffley and Miceli (1997) show that MSAs have the potential to induce socially efficient levels of health activities and preventive care, raising the expected wealth of consumers without reducing insurers' profits.

Watanabe (2005), on the other hand, finds that a HSA itself encourages health care consumption by lowering the effective price of health care. The cost-containment effect, in contrast, comes from the high deductible of the attached catastrophic insurance plan. The overall effect of the HSA program is ambiguous. Park, Greenstein and Friedman (2006) even warn that the "overfunding" of HSAs may encourage individuals to obtain additional elective health care services and increase total health expenditures. Remler and Glied (2006) conclude that due to the large amount of cost sharing that is already present in today's health insurance policies (e.g. FSAs or HRSs), the estimation results of older studies overpredict the potential cost savings of HSAs. Zabinski et al. (1999) use a microsimulation (MEDISIM) to show that a MSA combined with catastrophic health insurance will tend to crowd out comprehensive coverage. This results in premium spirals in the comprehensive coverage markets, which hurts poorer families and families with children. Hoffman and Schwartz (2006) and GAO (2006) report similar results.

The second goal of HSAs is concerned with increasing the number of individuals with health insurance. This is an important goal as there are 45 million uninsured Americans. HSAs promise to decrease premiums so that more people can afford health insurance. However, Glied and Remler (2005) estimate that the tax savings via HSAs will increase the number of newly insured adults by less than 0.3% of the current adult uninsured population. This small number is the result of the relatively low response rate of low income adults to buy insurance with additional income from tax savings. Low income adults are the largest group within the uninsured population (Hoffman and Schwartz (2006)).

We partly address the third goal of HSAs which is concerned with the effect of a fully funded system on savings and growth. Imrohoroglu, Imrohoroglu and Joines (1998) find that the introduction of tax favored retirement accounts with a modest annual contribution limit can increase the steady state capital stock by more than 6%. Whether HSAs will have a similar effect in the U.S. is questionable since there already exist a large number of tax sheltered savings vehicles. Poterba, Venti and Wise (1995) have shown that the introduction of tax preferred 401 (*k*) plan did increase net savings despite the availability of a close savings substitute like individual retirement accounts (*IRAs*). We do not model tax sheltered alternatives but find much smaller increases in steady state capital stock (around 1.5%) after the introduction of HSAs.

3 The Model

3.1 Demographics

We use an overlapping generations framework. Agents work for J_1 periods and then retire for $J - J_1$ periods. In each period there is an exogenous survival probability of cohort j which we denote π_j . Agents die for sure after J periods. Deceased agents leave an accidental bequest that is taxed and redistributed equally to all agents alive. Population grows exogenously at an annual net rate n . We assume stable demographic patterns, so that similar to Huggett (1996), age j agents make up a constant fraction μ_j of the entire population at any point in time.

The relative sizes of the other generations alive μ_j is recursively defined as

$$\mu_j = \frac{\pi_j}{(1+n)^{\frac{years}{J}}} \mu_{j-1},$$

where *years* denotes the number of years modeled. The relative size of agents dying each period

(conditional on survival up to the previous period) can be defined similarly as

$$\nu_j = \frac{1 - \pi_j}{(1 + n)^{\frac{\text{years}}{J}}} \mu_{j-1}.$$

3.2 Preferences

The consumer values consumption and health, so that her within period preferences are

$$u(c_j, h_j) = \frac{\left(c_j^{\eta_j} h_j^{1-\eta_j}\right)^{1-\sigma}}{1-\sigma},$$

where c is consumption, h is the health stock, η_j is the age dependent intensity parameter of consumption, and σ is the inverse of the relative risk aversion parameter.⁹

3.3 Production of Health

We use the idea of health capital as introduced in Grossman (1972). In this economy there are two commodities: a consumption good c and medical services m . The consumption good is produced via a neoclassical production function that is described later. We do not model a production sector for medical services. Each unit of consumption good can be transformed into $\frac{1}{p_m}$ units of medical care. All medical care is used to produce new units of health. The accumulation process of health is given by

$$h_j = \phi_j m_j^\xi + (1 - \delta(h_j)) h_{j-1} + \varepsilon_j, \quad (1)$$

where h_j denotes the current health status, $\phi_j m_j^\xi$ denotes the production of new health with inputs of medical care m_j and parameters $\xi > 0$, ϕ_j being an age dependent productivity parameter, and $\delta(h_j)$ is the health deterioration rate which depends on the current health status. This partly captures the “immediacy” of health expenditures. The longer the agent waits to treat her health shock, the larger the health depreciation becomes. Finally, ε_j is an age dependent health shock, where $\varepsilon_j \leq 0$. The relative price of health and consumption can be expressed as $p_m \left(\frac{1}{\phi \xi} m^{1-\xi}\right)$, where the term in brackets is the marginal contribution to health of an additional unit of health care.¹⁰

The agent has to decide how much to spend out-of-pocket on medical care. We only model discretionary health expenditures m_j in this paper. Income will have a strong effect on endogenous total medical expenses. Our setup assumes that given the same magnitude of health shock ε_j a richer individual will outspend a poor individual. This may be realistic in some circumstances. However, a large fraction of health expenditures are probably non-discretionary (e.g. health

⁹An alternative way of formulating this problem and reducing the state space would be to let total health expenditure m_j enter the utility function directly. We only model discretionary health expenditures (see next section for a discussion on health expenditures). Depending on the realization of the health state ε_j , the relative weight in the utility function of discretionary health expenditures m_j changes, so that

$$u(c_j, m_j, z_j) = \frac{\left(c_j^{\gamma_1} m_j^{\gamma_2(\varepsilon_j)}\right)^{1-\sigma}}{1-\sigma},$$

where $\gamma_2(\varepsilon_j)$ is a decreasing function in the health status variable ε_j . As the health state worsens, the consumer puts more weight on health expenditures in her utility function. Another way of thinking about this is health maintenance. If health deteriorates, the health maintenance costs are higher and therefore the consumer is willing to spend more on health care which establishes new relative rates of marginal utilities between consumption and health expenditures.

¹⁰Compare Suen (2006) for a similar formulation.

expenditures caused by a catastrophic health event that requires surgery etc.). In such cases a poor individual could still incur large health care costs. We do not cover this case in the current model.¹¹

Exogenous health shocks ε_j follow a Markov process with age dependent transition matrix P_j . Transition probabilities from one state to the next depend on the past health shock ε_{j-1} so that an element of transition matrix P_j is denoted

$$P_j(\varepsilon_j, \varepsilon_{j-1}) = \Pr(\varepsilon_j | \varepsilon_{j-1}, j).$$

3.4 Human Capital Profile

Effective human capital over the life-cycle evolves according to

$$e_j = \left(e^{\beta_0 + \beta_1 j + \beta_2 j^2} \right)^\chi \left(h_{j-1}^\theta \right)^{1-\chi} \text{ for } j = \{1, \dots, J_1\}, \quad (2)$$

where $\beta_0, \beta_2 < 0$, $\beta_1 > 0$ and $\chi \in [0, 1]$. This mimics a hump-shaped income process over the life-cycle and makes the wage income of agents dependent on their health state as well. Tuning parameter θ allows us to gradually diminish the influence of health on the production process and individual household income without holding the exogenous age dependent component fixed. This parameter determines to what degree health becomes an investment good.

3.5 Out-of-Pocket Medical Expenses and Insurance

We do not distinguish between group insurance (employer provided) and individual insurance (bought by individuals in the private insurance market).¹² We therefore combine elements of group insurance (e.g. tax deductibility of premium payments) with elements from the individual market (e.g. screening by age). We think this is a good compromise to make a statement about the entire private insurance market.

Cutler and Wise (2003) report that about two thirds of the population younger than 65 is covered by some form of private insurance. The majority of these contracts is offered via employment contracts and premiums paid are thus tax deductible. Only 10% of these contracts are bought directly from insurance companies by the households. Premiums for these contracts are not tax deductible.

In the model, the working agent can decide between a low deductible health insurance, a high deductible health insurance, or no health insurance. These health insurances are employer provided so that health insurance premiums are tax deductible. In addition, we assume that health insurance companies can screen the worker by age but not by health status.¹³ We can

¹¹One method to include this would be to distinguish between discretionary and non-discretionary health expenditures. The consumer can freely decide on how much to spend on discretionary health expenditures m_j (e.g. preventive health check-ups, upgrades in hospitals, etc.) but incurs non-discretionary health expenditures $\bar{m}(\varepsilon_j)$ which are a function of her health shock ε_j (e.g. hospital visits due to serious health problems, emergency health care, etc.). The total health expenditure would then be denoted

$$p_m \bar{m}(z_j) + p_m m_j.$$

¹²Jeske and Kitao (2005) present a model where this is modeled specifically.

¹³We are aware that employers are not allowed to discriminate according to health status or age when offering health insurance. However, given the discussion above, we think this is still an acceptable assumption. In addition, between 2000 and 2002, older workers experienced rising unemployment rates that were greater in relative magnitude than those for younger workers over the same period (Six (2003)). This suggests that older workers are more likely to lose their employer provided health insurance. They are then forced to buy insurance in the individual market, where they have to pay higher premiums because of their age.

interpret the model as if the employee can choose to work for three different types of employers. Employer one is offering a low deductible health insurance via an insurance company, employer two is offering a high deductible health insurance via a different insurance company, and employer type three offers no health insurance. The tax deductible health insurance premium that enters the workers budget constraint together with the wage income can then be interpreted as the effective wage income. As a consequence, an employee with a health insurance package receives a lower effective wage than an employee working a job without health insurance. Since we do not model employer matching we abstract from this process and simply claim that the employee can make the employment and insurance type choice. This also allows us to only have one representative firm that pays one wage rate. Employees then decide on their efficiency wage by deciding which insurance they want to have.

Insurance companies offer two types of health policies, a low deductible policy with deductible ρ and copayment rate γ at a premium p_j and a high deductible policy with deductible ρ' and copayment γ' at a premium p'_j . These premiums are tax deductible.

In order to be insured against a health shock, households have to buy insurance the period before their health shock is realized. Agents in their first period of life are thus not covered by any insurance. We distinguish between three possible insurance states $in_{j-1} = \{1, 2, 3\}$, where $in_{j-1} = 1$ is the state of having a low deductible health insurance in period j , $in_{j-1} = 2$ denotes the high deductible health insurance in period j and $in_{j-1} = 3$ indicates that the agent has no health insurance in period j . The household's out of pocket health expenditure when young and working if $j \leq J_1$ is therefore denoted

$$o^W(m_j) = \begin{cases} \min[p_{m,Ins}m_j, \rho + \gamma(p_{m,Ins}m_j - \rho)] & \text{if } in_{j-1} = 1, \\ \min[p_{m,Ins}m_j, \rho' + \gamma'(p_{m,Ins}m_j - \rho')] & \text{if } in_{j-1} = 2, \\ p_{m,noIns}m_j & \text{if } in_{j-1} = 3, \end{cases}$$

where $p_{m,Ins}$ is the relative price of health expenditures paid by insured workers and $p_{m,noIns}$ is the price of health expenditures paid by the uninsured worker. An uninsured worker pays a higher price $p_{m,noIns} > p_{m,Ins}$. The copayment rate γ is the fraction the household pays after the insurance company pays $(1 - \gamma)$ of the post deductible amount $p_{m,Ins}m_j - \rho$. Since households have to buy insurance before health shocks are revealed we assume that working households in their last period $j = J_1$ already decide to buy into Medicare.

After retirement all agents are covered by Medicare. Each agent pays a fixed premium p^{Med} every period for Medicare. Medicare then pays a fixed fraction $(1 - \gamma^{Med})$ of the health expenditures that exceed the amount of the deductible ρ^{Med} . The total out of pocket expenditures of a retiree are

$$o^R(m_j) = \min \left[p_{m,Med}m_j, \rho^{Med} + \gamma^{Med} (p_{m,Med}m_j - \rho^{Med}) \right], \text{ if } j > J_1 + 1,$$

where $p_{m,Med}$ is the price of health expenditures that retirees with Medicare have to pay. An agent's out of pocket expenses when retired can still be paid with funds from the HSAs. The Medicare premium also qualifies for penalty free deductions from HSAs. In addition, Medicare is financed by a payroll tax τ^{Med} . We assume that old agents $j > J_1 + 1$ do not purchase private health insurance and that their health costs are covered by Medicare and their own resources plus social insurance (e.g. Medicaid) if applicable.¹⁴

¹⁴ According to Jeske and Kitao (2005) many old agents purchase various forms of supplementary insurance. The fraction of health expenditures covered by such insurances is small. According to the Medical Expenditure Panel Survey (MEPS) 2001, only 15% of total health expenditures of individuals older than 65 is covered by supplementary insurances. Cutler and Wise (2003) report that 97% of people above age 65 are enrolled in Medicare which covers 56% of their total health expenditures. Medicare Plan B requires the payment of a monthly premium and a yearly

3.6 Health Savings Accounts

If agents buy a high deductible insurance they can decide on how many assets a_j^m they want to carry into the next period tax free at the market interest rate. Agents can only contribute to their HSA when they are younger than 65. Agents can pay their out-of-pocket medical expenses $o(m_j)$ directly with savings from their HSAs. If they oversave in HSAs they can roll over the account balance into the next period.¹⁵ Savings accumulate tax free.

If agents decide to use funds from the HSA to pay for non qualified health expenses, they have to pay a tax penalty at rate τ^m and forgone income tax. This penalty only applies to agents younger than 65 years. Agents older than 65 can use the money in their HSA for non-health related expenses without having to pay the tax penalty τ^m . However, they have to pay income taxes on income spent in this way.

If they undersave and the funds in the HSAs do not cover all medical expenses, then the household has to use standard savings income to finance her residual medical expenses and consumption when old. In addition, there is an upper limit on the annual contribution to an HSA which we denote \bar{s}^m .¹⁶

3.7 Households

Age j year old agents enter the period with state vector $x_j = (a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j)$, where a_{j-1} is the capital stock at the beginning of the period, a_{j-1}^m is the capital stock accumulated in HSAs at the beginning of the period, h_{j-1} is the health state at beginning of the period, in_{j-1} is the insurance state in period j (chosen by the agent in the previous period $j-1$), and $\varepsilon_j \in \{\varepsilon_{1j}, \varepsilon_{2j}, \varepsilon_{3j}, \varepsilon_{4j}, \varepsilon_{5j}\}$ is one of five possible negative health shocks where $0 \geq \varepsilon_{1j} > \varepsilon_{2j} > \dots, \varepsilon_{5j}$.

The state vector of a household not counting age j is defined as

$$x_j = \begin{cases} (a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) \in R_+ \times R_+ \times R_+ \times In^w \times R_- = D & \text{if } j \leq J_1, \\ (a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) \in R_+ \times R_+ \times R_+ \times In^R \times R_- = D & \text{if } j > J_1, \end{cases}$$

where $In^W = \{1, 2, 3\}$ and $In^R = \{1, 2\}$. Retired agents have only two insurance states, $In^R = 1$ they have Medicare Plan B and $In^R = 2$ they don't have Medicare Plan B in their first period of retirement. Thereafter all retirees are forced to have Medicare Plan B, so that $in_{j-1} = 1$, for $j > J_1 + 1$. For each $x_j \in D(x_j)$ let $\Lambda(x_j)$ denote the measure of age- j agents with $x_j \in D$. The fraction $\mu_j \Lambda(x_j)$ then denotes the measure of age- j agents with $x_j \in D$ with respect to the entire population of agents in the economy.

3.7.1 Workers (Younger than 65)

Agents receive income in the form of wages, interest income, accidental bequests, and social insurance. The latter guarantees a minimum consumption level of \underline{c} . After health shocks are realized, agents simultaneously decide their consumption c_j , stocks of capital for the next period a_j , and health expenditures m_j . They also pick the insurance state for next period $in_j = \{1, 2, 3\}$, which requires them to pay a premium p_j for $in_j = 1$, p'_j for $in_j = 2$, or nothing for $in_j = 3$.

deductible. See *Medicare and You* (2007) for a brief summary of Medicare.

According to MEPS data from 2003, only 1.35% of the population older than 65 is not covered by Medicare. The same survey finds that 10.13% have Medicaid and Medicare, 54.95% have Medicare and private insurance combined (62.97% of those have private group insurance whereas 36.89% have private individual insurance, the rest have some other form of private insurance combined with Medicare), and 33.57% have only Medicare. (Available at: http://www.meps.ahrq.gov/mepsweb/data_stats/download_data/pufs/pmep04/pmep04_table5.shtml)

¹⁵This feature distinguishes HSAs from Flexible Spending Accounts (FSAs).

¹⁶The contribution limit to HSA for 2007 for individuals is \$2,850. Compare <http://www.treas.gov/offices/public-affairs/hsa/07IndexedAmounts.shtml>

If agents decide to buy a high deductible insurance, i.e. if $in_j = 2$, then they are eligible to hold a_j^m in an HSA. If they do not purchase a high deductible insurance for the following period, then they are not eligible for HSAs anymore and they have to dissolve their existing HSAs completely.¹⁷

In their last period of work, agents decide whether to buy into Medicare Plan B. We make the assumption that premium payments for Medicare Plan B are not tax deductible and that agents can only continue to save in HSAs if they buy into Medicare Plan B. We later calibrate the model so that all workers in their last period buy into Medicare Plan B.¹⁸

With HSAs we have to distinguish in each period between agents who contribute to HSAs and those who take funds out of HSAs. Among those who do not contribute each period, we have to further distinguish between those that use these funds for health related expenses and those that use them for consumption. The latter have to pay a penalty tax τ^m when they are younger than 65 years old. In addition, they have to pay forgone income tax on funds withdrawn for non-qualified expenses.

The household problem for young agents $j = \{1, \dots, J_1 - 1\}$ who are net contributors can be formulated recursively as

$$V_j(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, m_j, a_j, a_j^m, in_j\}} \{u(c_j, h_j) + \beta \pi_j E_\varepsilon [V_{j+1}(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}) | \varepsilon_j]\} \quad (3)$$

s.t.

$$\begin{aligned} & c_j + a_j + 1_{\{in_j=2\}} a_j^m + o^W(m_j) + 1_{\{in_j=1\}} p_j + 1_{\{in_j=2\}} p_j' \\ = & \tilde{w}_j + R(a_{j-1} + T^{Beq}) + R^m a_{j-1}^m - Tax_j + T_j^{SI}, \\ h_j = & \phi_j m_j^\xi + (1 - \delta(h_j)) h_{j-1} + \varepsilon_j, \\ 0 \leq & NI_j \leq \bar{s}^m, \\ 0 \leq & a_j, a_j^m, \end{aligned}$$

¹⁷This is a simplifying assumption. What the law actually states is that if the policy holder ends her participation in the HDHP (High Deductible Health Plan), she loses eligibility to deposit further funds, but funds already in the HSA remain available for use. Since our period is actually 9 years long, we think that the assumption that the agent has to completely dissolve the account in that period is not too strong.

¹⁸Although Medicare Plan B payments are itemizable as qualified medical expenses in the income tax statement, there is the additional provision that says that only medical payments that exceed 7.5% of the adjusted gross income (Form 1040, line 38) are tax deductible. Compare the IRS publication at: <http://www.irs.gov/publications/p502/ar02.html#d0e299>

What we implicitly assume here is that Medical expenses do not exceed this limit and therefore premiums for Medicare are not tax deductible.

where

$$o^W(m_j) = \begin{cases} \min[p_{m,Ins}m_j, \rho + \gamma(p_{m,Ins}m_j - \rho)] & \text{if } in_{j-1} = 1, \\ \min[p_{m,Ins}m_j, \rho' + \gamma'(p_{m,Ins}m_j - \rho')] & \text{if } in_{j-1} = 2, \\ p_{m,noIns}m & \text{if } in_{j-1} = 3, \end{cases} \quad (4)$$

$$NW_j = R^m a_{j-1}^m - o^W(m_j), \quad (4)$$

$$NI_j = a_j^m - \max[0, NW_j],$$

$$\tilde{w}_j = (1 - 0.5\tau^{Soc} - 0.5\tau^{Med}) we_j, \quad (5)$$

$$Tax_j = \tilde{\tau}(\tilde{y}_j^W) + 0.5(\tau^{Soc} + \tau^{Med}) (\tilde{w}_j - 1_{\{in_j=1\}}p_j - 1_{\{in_j=2\}}p'_j),$$

$$\tilde{y}_j^W = \tilde{w}_j + ra_{j-1} + RT^{Beq} - NI_j,$$

$$T_j^{SI} = \max[0, \underline{c} + Tax_j - \tilde{w}_j - R(a_{j-1} + T_j^{Beq}) - (R^m a_{j-1}^m - o^W(m_j))].$$

Variable c_j is consumption, a_j is next period's capital stock, a_j^m is next period's capital stock in HSAs, \bar{s}^m is the maximum contribution into HSAs per period, $o^W(m_j)$ is out-of-pocket health expenditure, m_j is total health expenditure, p_j is the insurance premium for the low deductible health insurance, p'_j is the insurance premium for the high deductible health insurance, \tilde{w}_j is wage income net of the employer contribution to Social Security and Medicare, R is the gross interest rate paid on assets a_{j-1} from the previous period and accidental bequests T_j^{Beq} , Tax_j is total taxes paid¹⁹ and T_j^{SI} is Social Insurance (e.g. Medicaid and food stamp programs). The fact that we use \tilde{w}_j in the tax base for income tax $\tilde{\tau}(\tilde{y}_j^W)$ leads to a double taxation of a portion of wage income due to the flat payroll tax $0.5(\tau^{Soc} + \tau^{Med})\tilde{w}_j$ that is added. This mimics the institutional feature of income and payroll taxes.²⁰

NW_j is net wealth in the HSA after subtracting out-of-pocket health expenses, NI_j is net investment in the HSA, we_j is the effective wage income. The function $\tilde{\tau}(\tilde{y}_j^W)$ captures progressive income tax, $0.5(\tau^{Soc} + \tau^{Med})\tilde{w}_j$ is the payroll tax that the household pays for Social Security and Medicare, and $\tau^m NI_j$ is the penalty tax for non-qualified withdrawals from the HSA, \tilde{y}_j^W is the tax base for the income tax composed of wage income and interest income on assets and accidental bequests. We subtract net contributions NI_j to HSAs because they are tax deductible.

For net contributors it has to hold that $NI_j \geq 0$, that is, next periods funds a_j^m in the HSA have to be larger than the funds at the beginning of the period minus the allowed health related expenditures (e.g. out-of-pocket health expenses o^W that can be financed with HSA funds).

¹⁹If health insurance was provided by the employer, so that premiums would be partly paid for by the employer, then the tax function would change to

$$Tax_j = \tilde{\tau}(\tilde{y}_j^W) + 0.5(\tau^{Soc} + \tau^{Med}) (\tilde{w}_j - 1_{\{in_j=1\}}(1-\psi)p_j - 1_{\{in_j=2\}}(1-\psi)p'_j),$$

where ψ is the fraction of the premium paid for by the employer. Jeske and Kitao (2005) use a similar formulation to model private vs. employer provided health insurance. They pick $\psi = 0.85$ based on MEPS data in 1997. We simplify this aspect of the model and assume that all health insurance policies are offered via the employer and that the employee pays the entire premium, so that $\psi = 0$. The premium is therefore tax deductible in the employee (or household) budget constraint.

²⁰Compare Social Security Tax Reform (Art#3).

For net non-contributors the corresponding constraints are

$$NI_j < 0,$$

$$Tax_j = \tilde{\tau} (\tilde{y}_j^W) + 0.5 \left(\tau^{Soc} + \tau^{Med} \right) \left(\tilde{w}(\varepsilon_j) - 1_{\{in_j=1\}} p_j - 1_{\{in_j=2\}} p'_j \right) - \tau^m NI_j,$$

with all other constraints being the same as for contributors. Net non-contributors draw funds from HSAs beyond what is allowed so that $NI_j < 0$ and therefore pay the penalty tax τ^m on the part spent on non-health related expenditures $\tau^m NI_j$. In addition they pay the forgone income tax, since the term NI_j is negative and enters the base for taxable income \tilde{y}_j^W .

The Social Insurance program T_j^{SI} guarantees a minimum consumption level \underline{c} . If Social Insurance is paid out then automatically $a_j = a_j^m = 0$ and $in_j = 3$ (the no insurance state) so that Social Insurance cannot be used to finance savings, savings into HSAs and private health insurance.²¹

Agents can only buy insurance if they have sufficient funds to do so, that is whenever

$$p_j < \tilde{w}_j + R \left(a_{j-1} + T_j^{Beq} \right) + R^m a_{j-1}^m - o^W(m_j) - Tax_j, \text{ or}$$

$$p'_j < \tilde{w}_j + R \left(a_{j-1} + T_j^{Beq} \right) + R^m a_{j-1}^m - o^W(m_j) - Tax_j.$$

The social insurance program will not pay for their health insurance. In their last working period J_1 agents decide whether to buy Medicare insurance or not. This determines their insurance state in the first period of retirement. Agents have to enrol in Medicare in order to keep their HSAs. From $J_1 + 1$ onwards, all agents are forced into Medicare.

3.7.2 Retired Agents

Retired agents in their first period of retirement are insured under Medicare if workers in their last period decided to buy into Medicare Plan B. From then onwards we force retirees to buy into Medicare insurance until they die. Retirees in general, that is, all agents with age $j > J_1$ are not allowed to make tax exempt contributions to HSAs anymore (that is agents older than 65). So they are all classified as net non-contributors. In addition, the tax penalty τ^m for non-health expenditures of HSA funds does not apply anymore. However, if the individual uses HSA funds for non-health related expenditures, she has to pay income tax. Retirees can pay the Medicare insurance premium p_j^{Med} with funds from the HSA.

The household problem for a retired agent $j \geq J_1 + 1$ who is a non-contributor and pays no penalty can be formulated recursively as

$$V_j(a_{j-1}, a_{j-1}^m, h_{j-1}, in_{j-1}, \varepsilon_j) = \max_{\{c_j, m_j, a_j, a_j^m\}} \{u(c_j, h_j) + \beta \pi_j E_\varepsilon [V_{j+1}(a_j, a_j^m, h_j, in_j, \varepsilon_{j+1}) | \varepsilon_j]\}$$

s.t.

²¹The stipulations for Medicaid eligibility encompass maximum income levels but also maximum wealth levels. Some individuals who fail to be classified as 'categorically needy' because they have too many savings could still be eligible as 'medically needy' (e.g. caretaker relatives, aged persons older than 65, blind individuals, etc.)

We will therefore make the simplifying assumption that before the Social Insurance program kicks in the individual has to use up all her wealth. Jeske and Kitao (2005) follows a similar approach.

See <http://www.cms.hhs.gov/MedicaidEligibility> for details on Medicaid eligibility.

$$\begin{aligned}
c_j + a_j + a_j^m + o^R(m_j) + p_j^{Med} &= R(a_{j-1} + T_j^{Beq}) + R^m a_{j-1}^m - Tax_j + T_j^{Soc} + T_j^{SI}, \\
h_j &= \phi_j m_j^\xi + (1 - \delta(h_j)) h_{j-1} + \varepsilon_j, \\
NI_j &= 0, \\
0 &\leq a_j, a_j^m,
\end{aligned} \tag{6}$$

where

$$\begin{aligned}
o^R(m_j) &= \begin{cases} \min[p_{m,Med} m_j, \rho^{Med} + \gamma^{Med}(p_{m,Med} m_j - \rho^{Med})] & \text{if } in_{j-1} = 1, \\ p_m m & \text{if } in_{j-1} = 2, \end{cases} \\
NW_j &= R^m a_{j-1}^m - o^W(m_j) - p_j^{Med}, \\
NI_j &= a_j^m - \max[0, NW_j], \\
Tax_j &= \tilde{\tau}(\tilde{y}_j^R), \\
\tilde{y}_j^R &= r a_{j-1} + R T_j^{Beq} - NI_j, \\
T_j^{SI} &= \max[0, \underline{c} + o^W(m_j) + Tax_j + p_j^{Med} - R(a_{j-1} + T_j^{Beq}) - R^m a_{j-1}^m - T_j^{Soc}].
\end{aligned}$$

Non-contributors who use HSA funds for non-health related expenses have to pay income tax on these funds (no penalty τ^m applies for agents older than 65). Therefore only constraint (6) changes to

$$NI_j < 0,$$

and all other conditions are the same as in the previous case.

3.8 Insurance Companies

Insurance companies satisfy their budget constraint within each period. We allow for cross subsidizing across generations. The constraints for two insurance companies selling the low and high deductible health insurance respectively are

$$\begin{aligned}
(1 + \omega_1) \times \sum_{j=2}^{J_1+1} \mu_j \int [I_{\{in_j(x_j)=1\}} (1 - \gamma) \max(0, p_{m,Ins} m_j(x_j) - \rho)] d\Lambda(x_j) \\
= R \sum_{j=1}^{J_1} \mu_j \int I_{\{in_j(x_j)=1\}} p_j d\Lambda(x_j), \text{ and}
\end{aligned} \tag{7}$$

$$\begin{aligned}
(1 + \omega_2) \times \sum_{j=2}^{J_1+1} \mu_j \int [I_{\{in_j(x_j)=2\}} (1 - \gamma') \max(0, p_{m,Ins} m_j(x_j) - \rho')] d\Lambda(x_j) \\
= R \sum_{j=1}^{J_1} \mu_j \int I_{\{in_j(x_j)=2\}} p'_j d\Lambda(x_j),
\end{aligned} \tag{8}$$

where ω_1 and ω_2 are markup factors that determine the profits of insurance companies, $I_{\{in_j(x_j)=1\}}$ is an indicator function equal to 1 whenever agents bought the low deductible health insurance policy and $I_{\{in_j(x_j)=2\}}$ is an indicator function equal to one whenever agents bought the high deductible insurance. Since agents have to buy their insurance one period prior to the realization of the health shock, first period agents are not insured. In addition, this lag implies that insurance premiums gain interest over one period. We clear low and high deductible insurances separately by adjusting the respective premium. Profits are redistributed in equal amounts to all surviving agents. Alternatively, we could discard the profits (“thrown in the ocean”). In this sense we think of them as loading costs (fixed costs) associated with running private insurance companies.

3.9 Firms

There is a continuum of identical firms that use a standard Cobb-Douglas technology. Firms solve

$$\max_{\{K, L\}} \{AK^\alpha L^{1-\alpha} - qK - wL\}, \quad (9)$$

taking (q, w) as given.

3.10 Government

The government taxes workers' income (wages, interest income, interest on bequests) at a progressive tax rate $\tilde{\tau}(\tilde{y}_j)$ which is a function of taxable income \tilde{y} and finances the social insurance program T^{SI} as well as government consumption G . The government budget is balanced so that

$$G + \sum_{j=1}^J \mu_j \int T_j^{SI}(x_j) d\Lambda(x_j) = \sum_{j=1}^J \mu_j \int Tax_j(x_j) d\Lambda(x_j). \quad (10)$$

Government spending G plays no further role ("thrown in the ocean").

Accidental bequests are redistributed in a lump-sum fashion to all households

$$\sum_{j=1}^J \mu_j \int T_j^{Beq}(x_j) d\Lambda(x_j) = \sum_{j=1}^J \nu_j \int a_j(x_j) d\Lambda(x_j) + \sum_{j=1}^J \nu_j \int a_j^m(x_j) d\Lambda(x_j), \quad (11)$$

where ν_j denotes the deceased mass of agents aged j in time t . An equivalent notation applies for the surviving population of workers and retirees denoted μ_j .

The Social Security program is self-financing

$$\begin{aligned} & \sum_{j=J_1+1}^J \mu_j \int T_j^{Soc}(x_j) d\Lambda(x_j) \\ &= \sum_{j=1}^{J_1} \mu_j \int 0.5\tau^{Soc} we_j(x_j) + 0.5\tau^{Soc} \left(\tilde{w}_j(x_j) - 1_{\{in_j(x_j)=1\}} p_j - 1_{\{in_j(x_j)=2\}} p'_j \right) d\Lambda(x_j). \end{aligned} \quad (12)$$

The Medicare program is self-financing (and paid on a pay-as-you go basis so that the insurance premiums do not accumulate interest from last period)

$$\begin{aligned} & \sum_{j=J_1+1}^J \mu_j \int \left(1 - \gamma^{Med} \right) \max \left(0, m_j(x_j) - \rho^{Med} \right) d\Lambda(x_j) \\ &= \sum_{j=1}^{J_1} \mu_j \int \left[0.5\tau^{Med} we_j(x_j) + 0.5\tau^{Med} \left(\tilde{w}_j(x_j) - 1_{\{in_j(x_j)=1\}} p_j - 1_{\{in_j(x_j)=2\}} p'_j \right) \right] d\Lambda(x_j) \\ & \quad + \sum_{j=J_1+1}^J \mu_j \int p_j^{Med} d\Lambda(x_j). \end{aligned} \quad (13)$$

3.11 Equilibrium

Definition 1 *Given the exogenous, transition probabilities P_j , realizations of health shocks $\varepsilon_j = \{\varepsilon_{1j}, \varepsilon_{2j}, \varepsilon_{3j}, \varepsilon_{4j}, \varepsilon_{5j}\}_{j=1}^J$, the survival probabilities $\{\pi_j\}_{j=1}^J$ and the exogenous government policies $\{\tilde{\tau}(\tilde{y}(x_j)), \tau^K\}_{j=1}^J$, a competitive equilibrium **with health savings accounts** is a collection of sequences of distributions $\{\mu_j, \Lambda_j(x_j)\}_{j=1}^J$ of individual household decisions $\{c(x_j), a(x_j), a^m(x_j), m(x_j), in(x_j)\}_{j=1}^J$, aggregate stocks of physical capital and human capital $\{K, L\}$, factor prices $\{w, q, R\}$ such that*

(a) $\{c(x_j), a(x_j), a^m(x_j), m(x_j), in(x_j)\}_{j=1}^J$ solves the consumer problem (3),

(b) the firm first order conditions hold

$$\begin{aligned} w &= \alpha_2 \frac{Y}{L}, \\ q &= \alpha_1 \frac{Y}{K} \\ R &= q + 1 - \delta, \end{aligned}$$

(c) markets clear

$$\begin{aligned} K' &= S = \sum_{j=1}^J \mu_j \int (a(x_j) + a^m(x_j)) d\Lambda(x_j), \\ L &= \sum_{j=1}^{J_1} \mu_j \int e(j, x_j) d\Lambda(x_j), \end{aligned}$$

(d) the aggregate resource constraint holds

$$G + S + \sum_{j=1}^{J_1} \mu_j \int (c(x_j) + p_m(x_j) m(x_j)) d\Lambda(x_j) = Y + (1 - \delta) K,$$

(e) the government programs clear so that (11), (12), (13), and (10) hold,

(f) the budget constraints of insurance companies (7) and (8) hold

(g) the distribution is stationary

$$\Lambda(x_{j+1}) = \sum_{j=1}^J \mu_j \int 1_{\left\{a'=a(x_j), a^m'=a^m(x_j), m'=m(x_j)\right\}} P_j(\varepsilon', \varepsilon) d\Lambda(x_j),$$

where 1 is an indicator function.

We use a standard numeric algorithm to solve the model.²²

4 Calibration

This section mirrors the model section in its structure. We use the model without HSAs as the benchmark model in the calibration and target key ratios from the U.S. National Income Accounts (NIPA), the U.S. Census and the Medical Expenditure Panel Survey (MEPS). In addition, we match some features of the U.S. demographics and the U.S. life cycle profile. Table 1 contains a summary of all model parameters and table 2 contains policy parameters. The model is just identified. The number of free parameters and the number of moments we match in the data is 47. We indicate in tables 1 and 2 which moments were particularly influenced by the respective parameter. We next describe the calibration in more detail.

4.1 Demographics

One period is defined as 9 years. We have $J = 8$ periods, so that we effectively model households from age 20 to 92, that is 72 years. The annual conditional survival probabilities $\left\{\pi_j^a\right\}_{j=20}^{92}$ are

²²We discuss the algorithm in Appendix B, which is available on the authors' website at http://mypage.iu.edu/~juejung/Papers/hsa_appendixB.pdf

taken from the U.S. Life-Tables 2003.²³ Since one period is 9 years we have to transform the annual survival probabilities $\{\pi_j^a\}_{j=20}^{92}$ into per-period survival probabilities $\{\pi_j\}_{j=1}^J$ according to the following procedure

$$\pi_1 = \pi_{20}^a; \pi_2 = \Pi_{i=1}^9 \pi_{20+i}^a; \dots; \pi_J = \Pi_{i=1}^9 \pi_{20+8 \times (J-1)+i}^a.$$

We plot the survival curves in panel 1 of figure 1. We then recursively define the number of agents alive according to

$$\mu_j = \frac{\pi_j}{(1+n)^{\frac{years}{J}}} \mu_{j-1},$$

where we adjust the annual population weight n by the length of the period ($\frac{years}{J} = \frac{72}{8} = 9$ years in our 8 period model). We overstate the population growth rate $n = 2.5\%$ compared to the 1.2% population growth rate of the past 50 years in the U.S. in order to match the fraction of the old population.²⁴ Given our parameter choices, the total population over the age of 65 is 13.97% which is between the numbers in the U.S. Census (12.4%) and the 20% used in Jeske and Kitao (2005) who only look at heads of households.

4.2 Preferences

The relative risk aversion parameter takes a standard value, $\sigma = 1.5$. The weight of consumption in the utility function is age dependent and summarized in vector

$\eta_j = \{0.65, 0.95, 0.96, 0.96, 0.95, 0.85, 0.80, 0.80\}$. In conjunction with the magnitudes of the health shocks these weights ensure that the model matches total health spending and the take-up ratio of health insurance. We thereby assume that the very young and the very old have a higher preference weight on their health than the middle aged. We need the relatively large preference for health of the young generation in order for them to buy insurance in the model. The annual discount factor is $\beta = 1.025$ to match the capital output ratio and the interest rate.

4.3 Production of Health

The productivity parameter ϕ_j of the health production function is age dependent and summarized in vector $\phi = \{1.5, 1.5, 1.5, 1.5, 1.5, 1.5, 1.65, 1.65\}$. This is similar to the production parameter in Suen (2006) for a very similar production function of health. The second parameter is picked at $\xi = 0.35$. We do not have data on these parameters and conduct sensitivity analysis. We assume that health depreciation depends on the current health state but is independent of age and current health care spending. Health depreciates at rates between $\delta(h_j = h_{\min}) = 1 - 0.80^{(years/gJ)} = 0.8658$ and $\delta(h_j = h_{\max}) = 1 - 0.87^{(years/gJ)} = 0.7145$. We chose this structure so that health depreciates faster when the health state is already low. This feature captures the urgency of treatment. We pick these numbers to match total health expenditures in the economy and the take up ratios for insurance over the life-cycle. Section 5 contains a summary of how well the model matches the data.

4.3.1 Transition Probabilities

We estimate the health shocks in the law of motion of health capital using data from seven waves of the Health and Retirement Survey (HRS).²⁵ We first use a linear probability model and estimate expression (1) where we impose that health capital h_j can attain five possible

²³ ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/54_14/Table01.xls

²⁴ Compare: <http://www.susps.org/overview/numbers.html>

²⁵ We use the RAND-HRS version that contains survey data from 1992, 1994, 1996, 1998, 2000, 2002, and 2004.

health states. These health states correspond to five self reported health states in the HRS. In addition, we impose an $AR(1)$ structure on the health shocks (the errors in expression (1)).²⁶ After estimating the $AR(1)$ process for the shocks, we simulate health shocks for 10,000 agents for each of 10 starting health shocks that we obtain from the data. We then collect the shocks into five risk classes and label them from 1 (lowest shock) to 5 (highest shock). We then count how many of the simulated agents move from health shock 1 at age $j - 1$ to health shocks 1, 2, ..., 5 at age j . This will give us the conditional transition probabilities $P(\varepsilon_j | \varepsilon_{j-1} = 1)$. We follow the same procedure for $\varepsilon_{j-1} = \{2, 3, 4, 5\}$. We adjust for the period length of 9 years and allow for age group specific transition probabilities. In an eight period model this will result in seven 5×5 Markov switching matrices. Since we need one Markov switching matrix for each generation, we impose that the first two age groups have the same Markov switching matrix between health shocks.²⁷ All transition matrices for all 8 age groups are reported in table 1 in Appendix B which also contains the details about the estimation technique.²⁸

4.3.2 Magnitude of Health Shocks

The shocks to health $\varepsilon_j = \{\varepsilon_{1,j}, \varepsilon_{2,j}, \dots, \varepsilon_{5,j}\}$ are picked so that the insurance coverage take-up rate (percentage of workers buying the low deductible health insurance per age group) and the share of medical spending in GDP is approximated. Table 3 presents the matrix of age dependent health shocks associated with each one of the five health states.²⁹ In order to identify the model we put restrictions on the shock structure. Shocks 1, 2, and 3 do not change over age for worker and shocks 1, 2, 3, and 4 do not change over age for retirees. All other shocks are unrestricted, so that the number of free parameters from the 8×5 shock matrix is 20.

4.4 Human Capital Profile

Effective human capital evolves according to expression (2). We use the following estimates for $\{\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\} = \{8.12, 0.14, -0.0016\}$. These estimates are obtained by fitting a second order polynomial to summarized income data from the CPS (see *Income, Poverty, and Health Insurance Coverage in the United States: 2005* (2006)), according to

$$\log(\text{income}) = \beta_0 + \beta_1 \text{age} + \beta_2 \text{age}^2 + \varepsilon.$$

This represents the exogenous part of expression (2). We next take the endogenous part into account. We can get a better fit of the human capital profile when we slightly adjust β_2 . The model then reproduces the hump shaped average efficiency units of the human capital profile after

²⁶This step could also be estimated with an ordered logit specification, since health states are discrete and follow a natural ordering. The choice of the linear probability model allowed for easier incorporation of the $AR(1)$ error structure in a panel robust estimator, Stata's `xtregar` command. The results are not affected significantly by the choice of this estimator. For more details on using an ordered logit specification to estimate Markov transitions between health states and comparisons to other estimation techniques we refer to Jung (2006).

²⁷Alternatively we could estimate an $AR(1)$ process for the health shocks in expression (1) and then use Tauchen's method (see Tauchen (1986) or Heer and Maussner (2005) for more details) to transform the estimated $AR(1)$ process into a discrete Markov switching process. However, this method determines the Markov switching matrix $P(\varepsilon_j | \varepsilon_{j-1})$ along with the magnitudes of the shock vector $\varepsilon_j = \{\varepsilon_{1j}, \dots, \varepsilon_{5j}\}$ which resulted in very poor fits of the insurance take-up ratios. It turned out to be crucial to be able to choose the magnitudes of the shock vector ε_j so as to match the insurance take-up rates. We therefore decided to use the procedure described in the main text which only pins down the Markov switching matrix and allows for choosing the shock magnitudes separately.

²⁸Appendix B is available on the authors' website at: http://mypage.iu.edu/~juejung/Papers/hsa_appendixB.pdf

²⁹We were not able to match the medical expenditure profile. Medical expenditures of an average individual is roughly 20% of her income. Suen (2006) finds that the ratio of medical spending to income by age for 2000 is around 10% for individuals under age 65 and 60% for individuals over 65. The model overpredicts spending of the young generations and underpredicts spending of the old.

the health process is taken into account. Setting $\beta_2 = -0.0015$ results in the effective human capital profile depicted in panel 2 of figure 2. We normalized the profile and compare it to the normalized income profile from the data. Fernandez-Villaverde and Krueger (2004) show similar income patterns using data from the Consumer Expenditures Survey over the period 1980-1998. For parameter χ we pick 0.85. We pick this rather large weight on age because it produces more stable results as the feedback from the endogenous health choice is diminished. We also do not want to inflate the effects of health. We are not aware of any estimates for parameter χ and will therefore conduct sensitivity analysis. We set parameter $\theta = 1$ in the benchmark economy. This value ensures that health capital is also an investment good. We later conduct sensitivity analysis and completely turn off the investment function of health by setting $\theta = 0$. In this case health capital is a pure consumption good.

There is a growing empirical literature documenting the relationship between health and growth that can be divided into two branches. The first consists of microeconomic literature that examines the effects of varying health inputs on health outcomes themselves. Two of the most important inputs are food and medical services (e.g. Behrman et al. (2003)...).

The second branch concentrates on the effect of health on productivity and income. Bloom, Canning and Sevilla (2004) report that a one year increase in life expectancy raises output by 4 percent. They report results from 13 empirical studies that find similar quantitative results.

4.5 Out-of-Pocket Medical Expenses and Insurance

4.5.1 Age Dependent Insurance Premiums, Coinsurance Rates and Deductibles

Insurance premiums are age dependent. We use a base premium p_0 and an exogenous age dependent premium growth rate g_j to calculate the premium for each age group. We express the premium of j year old agents for high and low deductible health insurances as

$$p_j = p_0 \times g_j, \text{ and } p'_j = p'_0 \times g_j.$$

We estimate a common growth factor for insurance premiums (both low and high deductible insurance premiums grow at the same rate g_j for each age group j) g_j using summary data on individual health insurance premiums from *The Cost and Benefit of Individual Health Insurance Plans* (2005). We use a simple second order polynomial to fit the growth rate of age dependent premiums which results in an estimate of the following equation

$$g_j = x_0 + x_1 \times \text{age} + x_2 \times \text{age}^2 + \varepsilon.$$

The estimates for the regressors are $\{\hat{x}_0, \hat{x}_1, \hat{x}_2\} = \{0.7781, 0.0036, 0.0007\}$. We present the age dependent premium growth rates in panel 2 of figure 1.³⁰

For the coinsurance rate we follow Suen (2006) and pick $\gamma = 25\%$ for the low deductible insurance. The coinsurance rate for the high deductible insurance is slightly lower at $\gamma = 20\%$. We pick this number lower so that in the benchmark economy the majority of agents buys the low deductible insurance. The coinsurance rate for Medicare γ^{Med} is also 25%.³¹

³⁰Jeske and Kitao (2005) report comparable insurance premiums for different income groups. In their model with three worker age cohorts they find that workers in the third age group (50 – 65 years old) pay roughly 3 to 4 times as much in insurance premiums than workers in the first age cohort (20 – 35 years old). This is similar to our results.

Another summary of premiums per age that results in similar age markups is available at: www.ahipresearch.org/pdfs/Individual_Insurance_Survey_Report8-26-2005.pdf

³¹According to Medicare News from November 2005 the coinsurance rates for hospital services under the Out-patient Prospective Payment System (OPPS) will be reduced to 20% of the hospital's total payment. Overall, average beneficiary copayments for all outpatient services are expected to fall from 33% of total payments in 2005 to 29% in 2006.

Since deductibles are level variables, calibrating them is more involved because we need to find expression for suitable ratios that can be normalized. In the following we match the ratios of the deductibles against each other, that is ρ/ρ' and ρ/ρ^{Med} as well as some ratios of average insurance premiums to median income $(\sum_j \mu_j p_j)/med(income)$ and finally, ratios of deductibles themselves to median income and insurance premiums, e.g. $\rho/med(income)$, $\rho'/med(income)$, $\rho^{Med}/med(income)$, $\rho/\sum_j \mu_j p_j$, $\rho'/\sum_j \mu_j p'_j$, and $\rho^{Med}/\sum_j \mu_j p_j^{Med}$.

The average deductible for the low deductible insurance is around \$305 as reported in Fronstin and Collins (2006), whereas the average deductible for high deductible plans is around \$2,330.³² Since the data in Fronstin and Collins (2006) is highly aggregated we view the \$305 deductible for the low deductible insurances as a lower bound. The average deductible for Medicare plans is around \$1,076 according to the U.S. Department of Health and Human Services.³³ We then get the following ratios: $\frac{\rho}{\rho'} = \frac{305}{2,330} = 0.13$ and $\frac{\rho}{\rho^{Med}} = \frac{305}{1,076} = 0.28$.

There is conflicting information as to the premiums of low vs. high deductible insurances. According to the National Center for Policy Analysis (NCPA) choosing a catastrophic health insurance plan can drop premiums significantly, some estimates claim by as much as 25% to 50%.³⁴ According to Claxton, Gabel, Gil, Pickreign, Whitmore, Finder, DiJulio and Hawkins (2006) the average annual premium paid by an individual is \$4,049 for an HMO, \$4,385 for a PPO, \$4,168 for a POS, and \$3,405 for a high deductible plan. Using these numbers the ratio of average premiums of high vs. low deductible insurances is $\frac{\sum_j \mu_j p_j}{\sum_j \mu_j p'_j} = \frac{4,100}{3,405} = 1.2$.

On the other hand, Fronstin and Collins (2006) report that average premiums of high deductible insurances tend to be higher than average premiums of low deductible insurances. This is explained by the fact that more people in high deductible plans buy coverage through the individual market and therefore have to pay the full cost of their premiums. People with high deductible plans offered by their employers are more likely to be employed by small firms which face higher premiums than large firms. According to their results average premiums for comprehensive (low deductible) plans are roughly \$1,203 whereas average premiums for high deductible plans were around \$2,027. These numbers result in a ratio of average premiums for low vs. high deductible insurances equal to $\frac{\sum_j \mu_j p_j}{\sum_j \mu_j p'_j} = \frac{1,203}{2,027} = 0.6$.

According to the U.S. Department of Health the premium for Medicare Part A is \$393 per month in 2006. This premium is however not paid by 99% of beneficiaries. The premium for Medicare Part B is $\$88.50 \times 12 = \$1,062$ per year which is roughly a fourth of the average premium paid by individuals who are still working.³⁵ We therefore find that the ratio of the average low deductible insurance premium to the average Medicare premium is around $\frac{\sum_j \mu_j p_j}{\sum_j \mu_j p_j^{Med}} = \frac{1,203}{1,062} = 1.13$ using the data from Fronstin and Collins (2006). If we use the data from Claxton et al. (2006) we have $\frac{\sum_j \mu_j p_j}{\sum_j \mu_j p_j^{Med}} = \frac{4,100}{1,062} = 3.86$. We use these numbers as respective lower and upper

Visit: <http://www.cms.hhs.gov/apps/media/press/release.asp?Counter=1506>

³²A 2005 national employer health benefits survey (as reported in GAO (2006)) found that employers' HSA-eligible plan deductibles were, on average, nearly six times greater than those for employers' traditional plans. This is very close to the ratio we use here.

³³Compare: <http://www.cms.hhs.gov/apps/media/press/release.asp?Counter=1557>

³⁴<http://www.ncpa.org/prs/cd/2005/20050829.htm> or <http://www.insureme.com/content/rsrc/health/catastrophic-health-insurance/?Refby=615245&gclid=CP7S1d7LoIwCFRlmWAod5Xk0PA>

According to www.hsasale.com, a website specializing in providing HSA insurance to individuals and businesses, it is claimed that traditional low deductible insurance premiums are almost 3 times as large as high deductible insurance premiums.

GAO (2006) reports that in a 2005 national employer health benefit survey it was found that HSA-eligible premiums were on average 35% less than traditional plans premiums for single coverage and 29% less for family plans.

³⁵Compare: <http://www.cms.hhs.gov/apps/media/press/release.asp?Counter=1557>

bounds.

In the next step we try to relate the deductibles and the insurance premiums to median income. According to data from the U.S. Census real median household income in the United States reached \$46,326 in 2005. Factoring in the average household size of 2.6 in 2005 we get a median per capita income of \$46,326/2.6 = 17,817 which results in ratios of: $\frac{\rho}{\text{med}(\text{income})} = \frac{305}{17,817} = 0.017$,

$$\frac{\rho'}{\text{med}(\text{income})} = \frac{2,330}{17,817} = 0.13, \quad \frac{\rho^{\text{Med}}}{\text{med}(\text{income})} = \frac{1,076}{17,817} = 0.0604, \quad \frac{\sum_j \mu_j p_j}{\text{med}(\text{income})} = \frac{\$1,203}{\$46,326/2.6} = 0.07, \text{ and}$$

$$\frac{\sum_j \mu_j p_j}{\text{med}(\text{income})} = \frac{\$4,100}{\$46,326/2.6} = 0.2301.^{36}$$

Finally, we relate the deductibles themselves to the average premiums paid. We get the following deductible vs. average premium ratios for the low deductible plan $\frac{\rho}{\sum_j \mu_j p_j} = \frac{305}{4,100} = 0.076$ and $\frac{\rho}{\sum_j \mu_j p_j} = \frac{305}{1,203} = 0.25$. For the high deductible plan we have $\frac{\rho'}{\sum_j \mu_j p_j} = \frac{2,330}{3,500} = 0.66$ and $\frac{\rho'}{\sum_j \mu_j p_j} = \frac{2,330}{2,027} = 1.15$, and for Medicare it is $\frac{\rho^{\text{Med}}}{\sum_j \mu_j p_j^{\text{Med}}} = \frac{1,076}{1,062} = 1$.

In our benchmark model without HSAs, the average premium for low deductible insurance is 0.88 vs. 1.22 for the high deductible insurance and the premium for Medicare is 0.72. These premiums result in premium ratios that are close to the ratios in the data. All ratios, data and model generated, are reported in table 9.

4.5.2 Price of Medical Services

In order to pin down the relative price of consumption goods vs. medical care goods, we use the average ratio of the consumer price index (*CPI*) and the Medical *CPI* between 1992 and 2006. We calculate the relative price to be $p_m = 1.52$.³⁷

The price of medical services for uninsured agents is higher than for insured agents. Various studies have pointed to the fact that uninsured individuals pay up to 50% (and more) higher prices for prescription drugs as well as hospital services (see *Playing Fair, State Action to Lower Prescription Drug Prices* (2000)). Kaiser (2000) of the Kaiser Foundation reports that the uninsured pay 14.6% higher prescription drug prices (not counting promotions for insurers). Their summaries are based on a study by the U.S. Department of Health and Human Services (see *Prescription Drug Coverage, Spending, Utilization, and Prices: Report to the President* (2000)). Anderson (2007) finds that the uninsured pay up to 2.5 times the amount that insured patients pay when hospital services are included. Finally, Brown (2006) finds that uninsured consumers in California pay 65% more for common prescription drugs than the federal government does for the same medications. The national average is a markup of around 60% for the uninsured population.

We therefore pick a markup factor of 1.6 so that $p_{m,nIns} = 1.6 \times p_{m,Ins}$. According to the U.S. Census 2004, the fraction of the population without insurance is roughly 15.7%.³⁸ Using all this information we solve the following system of equations for the relative prices that the insured and uninsured pay for medical services

$$\begin{cases} 1.52 = 0.843 \times p_{m,Ins} + 0.157 \times p_{m,nIns}, \\ p_{m,nIns} = 1.6 \times p_{m,Ins}, \end{cases}$$

which results in $p_{m,nIns} = 2.2226$ and $p_{m,Ins} = 1.3891$. This assumes that the overall price difference between consumption and health services is a weighted average of the prices that the

³⁶For the U.S. Census data compare: http://www.census.gov/Press-Release/www/releases/archives/income_wealth/007419.html and http://factfinder.census.gov/servlet/ACSSAFFacts?_submenuId=factsheet_0&_sse=on

³⁷Compare: <http://data.bls.gov/cgi-bin/surveymost?cu>

³⁸<http://www.census.gov/hhes/www/hlthins/hlthin04/hlth04asc.html>

insured and uninsured pay for health services.

4.6 Health Savings Accounts

There is an annual contribution limit to HSAs. According to the Revenue Procedure 2006-53 the upper limit is $\bar{s}^m = \$2,850$ for an individual ($\$5,650$ for a family).³⁹ In order to relate the level of the upper limit to variables in the model we will tie the contribution limit to the deductible using the following formula

$$\bar{s}^m = \rho' \times (1 + \nu),$$

where ν is a markup on the high deductible ρ' . Since the average high deductible is around $\$2,330$ according to Fronstin and Collins (2006) we get a markup factor of $(1 + \nu) = \frac{\bar{s}^m}{\rho'} = \frac{\$2,850}{\$2,330} = 1.2232$. We start with $\nu = 0.2232$ markup in the benchmark economy and conduct sensitivity analysis in figure 6, where we use the following savings limits: $\bar{s}^m = \{\$2,680; \$2,850; \$3,025; \$3,455; \$4,310; \$4,800; \$5,650\}$. The tax penalty for withdrawing funds that are not used for eligible health expenses is $\tau^m = 10\%$.

4.7 Insurance Companies

The fraction of insured in our model economy is highly sensitive to the equilibrium prices of insurance contracts. We start the baseline model with a zero profit condition on insurance companies, $\omega = 0$, and let the base premiums p_0 and p'_0 adjust to satisfy the the budget constraint of the insurance companies.

4.8 Firms

We choose a standard capital share in production of $\alpha = 0.33$. Total factor productivity $A = 4$. Nadiri and Prucha (1996) report estimates for depreciation rates of physical capital of 5.9% and depreciation of R&D capital is 12%. In our model we pick a capital depreciation rate of $\delta = 10\%$ which is a standard value in the calibration literature (e.g. Kydland and Prescott (1982)). The depreciation per period is then $1 - (1 - \delta)^{(\text{years}/J)} = 1 - 0.9^{72/8} = 0.6126$.

4.9 Government

The tax penalty for withdrawing funds from HSAs before the age of 65 and using them on non-health related consumption is $\tau^m = 10\%$. Social security taxes are $\tau^{Soc} = 2 \times 6.2\%$ on earnings up to $\$97,500$. This contribution is made by both employee and employer. The Old-Age and Survivors Insurance Security tax rate is a little lower at 10.6% and has been used by Jeske and Kitao (2005) in a similar calibration. We therefore match τ^{Soc} at 10.6% picking the appropriate pension replacement ratio Ψ to be 21%.⁴⁰ The size of the social security program is then 6% of GDP. This is close the number reported in *The 2002 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds* (2002) which is 5% for 2002.

Medicare taxes are $\tau^{Med} = 2 \times 1.45\%$ on all earnings again split in employer and employee contributions (see *Social Security Update 2007* (2007)). In order to get an appropriate premium

³⁹ Compare http://www.treas.gov/offices/public-affairs/hsa/pdf/all-about-HSAs_051807.pdf

According to the original rule of the Medicare Modernization Act of 2003 the maximum contribution to an HSA per year was the lesser of the amount of the high deductible ρ' or the upper limit $\bar{\rho} = \$2,850$ for an individual ($\$5,650$ for a family) so that the maximum contribution \bar{a}^m was $\bar{a}^m = \min[\rho', \bar{\rho}]$.

⁴⁰ Social security transfers are defined as $T_j^{Soc}(x) = \Psi we_j(h_{j-1})$ and they are the same for all agents. Transfers are a function of the active wage of a worker in her last period of work, so that $j = J_1$. In addition we assume that h_{j-1} is a constant and the same for all agents. We pick it to be equal $\frac{h_{0,J_1} + h_{gridh,J_1}}{2}$, which is the “middle” health state of the health grid vector. Biggs, Brown and Springstead (2005) report a 45% replacement rate for the average worker in the U.S. and Whitehouse (2003) finds similar rates for OECD countries.

for Medicare p^{Med} , so that the Medicare premium is lower than the private health insurance premiums, we have to pick the payroll tax (which helps to finance Medicare) sufficiently high. We pick $\tau^{Med} = 4\%$ which leads to a slightly larger Medicare program (4.44% of GDP) than what we observe in the data (2.5% of GDP according to *2002 Annual Report of the Board of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds* (2002)).

The income tax rates are summarized in table 4 and reflect U.S. income tax rates as of 2005. We follow Guner, Kaygusuz and Ventura (2007) and estimate the following equation using the information in table 4

$$marginalTaxRate(income) = \beta_0 + \beta_1 \log(income) + \varepsilon, \quad (14)$$

where $marginalTaxRate(income)$ is the marginal tax rate that applies when taxable income equals $income$. Variable $income$ is household income normalized with an assumed maximum income level of \$400,000. That is, we divide all income information in table 4 by \$400,000 and fit equation (14) to the normalized income data. The estimated coefficients for the tax function are then $\hat{\beta}_0 = 0.3411$ and $\hat{\beta}_1 = 0.0659$ so that the income tax function becomes

$$T(income) = \overbrace{[0.3411 + 0.659 \times \log(income)]}^{marginalTaxRate(income)} \times \text{taxable income}, \quad (15)$$

where $T(income)$ is total income tax paid. In addition, we impose a lower boundary of 0% and an upper boundary of 35% on the marginal income tax rate. Picking the maximum income level at \$400,000 will affect the estimates for the marginal tax function in (14) since it will determine the “tax bins” that individuals fall into. We report a graph of the approximation of the marginal tax rate against the tax code in panel 3 of figure 1. Note that the approximated marginal income tax is slightly below the marginal income tax from the tax code. We think this is justified since we do not explicitly account for negative income tax of low income households, tax loopholes, and the fact that marginal income taxes only apply for the specific brackets.

In our model, we similarly normalize taxable income of every agent with the maximum income of the richest agent in the economy to get the normalized variable $income$. We use this normalized income directly in (15) to get the marginal tax rate and the sum total of payable income tax for each individual.⁴¹ Since income tax revenue is collected to pay for the social insurance program T^{SI} (e.g. foodstamps, etc.) and the residual becomes government consumption G , we want to make sure that the size of government consumption also conforms to the data. The maximum income level of \$400,000 we chose earlier (when estimating the tax function) together

⁴¹Two other methods are known to us to determine the marginal income tax rate of an individual. The first is to use the tax structure given in table 4 directly to determine the marginal income tax for each individual. Assuming again a maximum income level of \$400,000 and then dividing the income groups into percentiles using this upper bound would determine the marginal income tax of a particular individual. This method introduces more discontinuities than the smooth tax function of the earlier method.

Second, Gouveia and Strauss (1994) estimate a similar tax function that mimicks the progressivity of the U.S. income tax system. This functional form is

$$\tilde{\tau}(\tilde{y}) = a_0 \left(\tilde{y} - (\tilde{y}^{-a_1} + a_2)^{-\frac{1}{a_1}} \right),$$

where y is total income earned and $\tilde{\tau}(\tilde{y})$ represents total taxes paid. Parameter a_0 is the limit of marginal taxes in the progressive part as income goes to infinity, a_1 determines the curvature of marginal taxes and a_2 is a scaling parameter. Average and marginal tax rates are then $\frac{\tilde{\tau}(\tilde{y})}{\tilde{y}} = a_0 \left(1 - (1 + a_2 \tilde{y}^{a_1})^{-\frac{1}{a_1}} \right)$ and $\tilde{\tau}'(\tilde{y}) = a_0 \left(1 - (1 + a_2 \tilde{y}^{a_1})^{-\frac{1}{a_1} - 1} \right)$ respectively. This functional form is often used in calibrated life-cycle modelling (e.g. Smyth (2005), Jeske and Kitao (2005) and Conesa and Krueger (2005)). We think the method described above fits our purpose best and approximates the U.S. income tax structure well.

with the model generated income across agents allows for $\frac{G}{Y} = 20.3\%$ compared to 20.2% reported in Castaneda, Diaz-Gimenez and Rios-Rull (2003). The marginal income tax function with the assumed upper limit in income of \$400,000 produces a very good approximation of the government size.⁴²

5 Numerical Results of the Benchmark Model

In this section we report the results of the benchmark model without HSAs.

5.1 Number of Insured Workers in Low and High Deductible Health Plans

Panel one in figure 2 shows the fraction of insured workers and distinguishes between private and public insurance. We overlay the information from the data with the insurance take-up ratios from the model. For the latter we distinguish between low and high deductible health insurance. In the model we concentrate on private insurance for workers and public insurance (Medicare) for retirees. We see that the model slightly underestimates the take-up rate of insurance for young workers and overestimates the take-up rate for older workers.

We calibrate the fraction of agents buying the low deductible insurance to be 51% and the fraction buying the high deductible insurance at 2.5% of all workers. These are underpredictions caused by the modelling assumption that requires agents to buy insurance one period prior to being insured. Therefore, the first generation of workers is always uninsured by construction and will “artificially” decrease the fraction of uninsured workers. Once we exclude the first generation and calculate the fraction of insured workers from the second period onwards we find that about 76.5% of workers buy private health insurance. The split between low and high deductible insurance is 95.4% vs. 4.6%. According to MEPS data of 2005, 86.1% of the population under age 65 do have health insurance, of which 70.1% is private and 16% is public. In addition, almost 100% of all retired workers do have health insurance.

The model’s low take up ratio for the high deductible insurance needs some justification. First, the data is ambiguous on the market share of low vs. high deductible insurance. Table 6 presents the percentage of health insurance policies grouped by the size of the deductible.⁴³ We see that roughly 57% of all privately purchased insurances by individuals have a deductible that is larger than \$1000 dollars and that 39% of all plans purchased by families have a deductible exceeding \$2000. This survey indicates that a large portion of the population might already hold high deductible insurance policies that would entitle them to have HSAs. These numbers present a stark contrast to a survey by Fronstin and Collins (2006) who sampled 3,158 privately insured adults between age 21 and 64. They find that enrollment in HDHPs that would qualify for HSAs is roughly 8% and that only 1% is currently holding HSAs.

We think that the second data source is more reliable. Since the benchmark model is the one without HSAs accounts, we practically model the situation in the U.S. prior to 2003. We therefore think the low take up rate of high deductible insurances of only 4.6% is justified.

⁴²The average marginal income tax rate $\bar{\tau}$ is estimated to be between 21.5% to 32.1% according to Stephenson (1998) and Barro and Sahasakul (1986) respectively. Our model’s average marginal tax rate is lower at 11%.

⁴³The data is from a sample of more than 62,000 individual and family health insurance policies purchased through www.eHealthInsurance.com in March 2004, on which premiums were paid in the preceding months since August 2003. This semi-annual study is designed to monitor the cost and comprehensiveness of benefits included in health insurance policies purchased by consumers, representing what is available to 94 percent of the U.S. population.

5.2 Medical Expenditures

We match two important measures of medical expenditures; the share of medical spending as a fraction of GDP and the distribution of medical expenditures by population size.⁴⁴

First, the model overstates total medical expenditures in terms of GDP which is roughly 16% according to Baicker (2006). The model reports 17.6%.

Second, we report the distribution of health care expenditure by population size in table 7. The data of the health expenditure concentration is from MEPS 2002 as summarized in Yu and Ezzati-Rice (2005). We see that a small share of the population is responsible for a large amount of total health expenditures e.g. 1% of the population is responsible for 22% of total health expenditures, 10% percent of the population spends almost 64%, and 50% of the population spends 97%. The model matches the high concentration of health care expenditures fairly well. The model slightly understates the concentration of the 1% of highest spenders to spend 20.6% of the total amount spent on health vs. 22% reported in the data. The model underpredicts the concentration of health care spending if we look at larger shares of the population. At higher percentages the model's match improves again. The 50% of the highest spenders of health care are responsible for 92.5% of total health expenditures in the model which is close to the 97% in the data.

5.3 Wealth Distribution

Table 8 reports the asset and income distributions of the model by quintiles and compares them to data. The data is from Diaz-Gimenez, Quadrini and Rios-Rull (1997) and from Budria-Rodriguez, Diaz-Gimenez, Quadrini and Rios-Rull (2002). The model does not match the wealth and income distributions accurately. One of the main reasons is the lack of a bequest motive. We therefore cannot match the high wealth concentrations that we observe in U.S. data. Including a bequest motive into the current framework poses a challenge, both on theoretical as well as on computational grounds.⁴⁵ The wealth Gini coefficient is 0.73 which is smaller than the 0.80 from 1998 data but closer than the Gini coefficient in Jeske and Kitao (2005) who report 0.5704 in their calibration. Their model also lacks a bequest motive. The Gini coefficient of income is 0.43 in the model compared to 0.553 from Budria-Rodriguez et al. (2002).

Second, Panel 3 in figure 2 shows the asset distribution over various age groups. We see that the model reproduces the hump shaped pattern in the data. The data is from the U.S. Census in 2000.⁴⁶

⁴⁴ Another measure of health expenditures, the medical expenditure profile, is not matched well by the model. The model overstates health care spending of the young as a fraction of their income and understates the fraction of health spending as a percentage of income of the elderly.

⁴⁵ Since an overlappings generations model with a bequest motive has properties of an infinite horizon model, we would not be able to simply solve the model backwards anymore but would have to iterate on the value function. This would require for the conditions of the contraction mapping theorem to hold. Since we use various step functions in the model (e.g. tax penalty) in addition to the discrete insurance choice setup, we are not positive whether monotonicity of the value function still holds in which case the contraction mapping theorem would break down.

Computationally the introduction of a bequest motive means that the algorithm that we use so far would have to be applied repeatedly until convergence of the value function. The current version of the model runs roughly 7 to 8 hours on Indiana University's supercomputer using optimized Fortran code. Repeated execution of the algorithm would increase computation time accordingly with no guarantee of convergence due to non-convexities.

⁴⁶ Compare http://www.census.gov/hhes/www/wealth/1998_2000/wlth00-1.html for the asset age distribution.

6 Policy Experiments

Table 10 reports steady state outcomes for six policy regimes. We normalize output, capital, health expenditures, consumption, welfare and all insurance premiums in the benchmark economy to 100. The first regime, the benchmark economy, allows workers to choose between a low and a high deductible insurance and forces retirees into Medicare. Steady state results are presented in column one of table 10. We have already discussed the calibration of this regime in the previous section. We then model the introduction of *HSAs* under alternate policy specifications. In all of these experiments we will concentrate on the number of insured workers and the fraction of aggregate health expenditures as percentage of GDP. We then investigate the effects on savings, output, insurance prices, insurance composition, and the wealth distribution.

6.1 Regime 2: Health Savings Accounts

The introduction of HSAs (2nd column in table 10 and figure 3) decreases aggregate health expenditures as a fraction of GDP from 17.6% to 14.4%. At the same time, the total fraction of insured individuals decreases from 80% to 75%.

With the introduction of HSAs agents shift savings from standard assets into their HSAs. Total savings increase by 1.2% compared to the benchmark model.⁴⁷ Aggregate health capital decreases as a consequence of the lower expenditure on health services (decrease in health capital of 5.5%). The overall effect of the increase in physical capital and the decrease in health capital is a 3% decrease in output. This will lower income of the households.⁴⁸

On the other hand, after HSAs are introduced the relative price for the high deductible insurance declines. More agents buy the high deductible insurance. The high deductible reduces moral hazard and agents demand fewer of the discretionary health services. This effect decreases total health expenditures.

HSAs increase the average price of discretionary health services relative to consumption. Therefore, consumption increases by 7% as consumers shift their expenditures from health services into consumption. Another consequence of this change in the relative price is that 52% of all retirees spend money saved in HSAs on non-health related consumption which forces them to pay the forgone income tax. Agents therefore seem to “oversave” in HSAs, so that when they retire they have excess funds to spend. This is consistent with results from GAO (2006) which state that only half of the owners of HSAs have actually withdrawn funds in 2004 to pay for their health treatments. Finally, government tax revenue decreases due to the tax preferred treatment of savings in HSAs. We therefore observe an adverse effect on government spending, a decrease from around 20% of GDP to 15% of GDP. HSAs are therefore very likely to add to fiscal deficits (see Park, Greenstein and Friedman (2006)).

6.1.1 Insurance

The insurance landscape changes dramatically. The fraction of agents buying the low deductible insurance decreases from 73% to 11%, whereas the fraction of agents buying the high deductible insurance increases from 3.6% in the benchmark economy to 59%. The introduction of HSAs

⁴⁷Poterba, Venti and Wise (1995) have shown that the introduction of tax preferred 401 (*k*) plan did increase net savings despite the availability of a close savings substitute like individual retirement accounts (*IRAs*). A HSA which substitutes away from traditional insurance with low deductibles to high deductible insurances is therefore likely to increase net savings. Since we do not model IRAs or 401 (*k*) plans in this model we cannot quantify this effect.

⁴⁸Bloom, Canning and Sevilla (2004) estimate that a one-year improvement in a population’s life expectancy contributes to an increase of 4% in output. They conclude that since this effect is so large, an increase in expenditures on improving health may be justified purely on the grounds of its impact on labor productivity, quite apart from the direct effect of improved health on welfare.

decreases the average insurance premiums of both, the low and the high deductible insurance. This has to do with some of the high risk agents moving out of the low deductible insurance into the high deductible insurance, so that the premiums for low deductible insurances drop. Overall the decrease in the insurance premiums is not enough to compensate for the loss of income from the lower output, so that overall the number of uninsured individuals increases.

The Medicare premium increases drastically by 29%. This has to do with the lower health states of all agents which increases the marginal utility of health at higher ages. Since we force all agents older than 65 into Medicare, these agents then use the insurance to “replenish” their low health especially in the context of the larger health shocks at higher ages. The increase in the Medicare premium is then the direct effect of the requirement that the program has to satisfy the Medicare budget constraint.

The Gini coefficient decreases slightly from 0.728 to 0.713 and welfare increases moderately from -100 to -97 .

6.1.2 Shifts in the Number of Insured Workers

Figure 4 shows the fraction of insured workers (low deductible insurance or high deductible insurance) for regime [1] and regime [2]. We track the number of insured workers per age group, income quintile, and health capital status and compare how the insured population changes when we introduce HSAs. From panel 1 we see that the very young lose their insurance coverage after the introduction of HSAs whereas the group of the middle aged gains coverage. Panel 2 indicates that no particular income group stands to lose insurance coverage disproportionately. Panel 3 shows that HSAs increase coverage of the “sicker” population with lower health capital, whereas coverage of the high health capital group drops. This is contrary to the findings in Greene et al. (2006) who report that healthier individuals are more likely to have HSAs. The discrepancy can be explained by the full information structure of our model and the long run equilibrium result of our solution. Greene et al. (2006) results are based on 2004 data and reflect the short experience of their survey participants with HSAs. Finally, in panel 4 we illustrate the change in health capital holdings per age group before and after the introduction of HSAs. We see that the drop in health capital predominantly affects middle age workers. Health capital over age does not follow a hump shape pattern. When Medicare becomes available, agents have access to relatively cheap health services and start replenishing their health stocks at higher ages. This effect becomes more extreme with the introduction of HSAs because HSAs kept the health capital at lower levels than in the benchmark economy.

6.1.3 Who Saves in HSAs?

Panel 1 in figure 5 reports the average percentage of asset holdings in HSAs by age together with the fraction of the population having HSAs. We find that there is a non-linear relationship. The young and the old hold more of their assets in the form of funds in HSAs, whereas the middle-aged have a smaller fraction of their assets invested in HSAs. However, the middle aged are more likely to have HSAs. The fact that none of the 30 year old agents buy the high deductible insurance is consistent with the argument made by Hoffman and Tolbert (2006). They claim that low income families do not get any additional income from tax shelters, so that HSAs, especially together with the high deductibles, are unattractive to them. Also, the model does not indicate a clear pattern of which age cohorts are more likely to have HSAs which confirms the findings in GAO (2006).

Panel 2 graphs the percentage of asset holdings in HSAs and the percentage of the population with HSAs per income quintile. We find that the annual contribution limit ensures that the higher income households cannot shift a larger proportion of their income into HSAs. In fact, they hold less of their assets in HSAs. Holdings in HSAs as a fraction of annual household income

is a decreasing function of the income status of the household. However, richer households are more likely to have HSAs. This is consistent with the results in GAO (2006) that HSA plan enrollees have higher income than households in comparison groups.

Panel 3 illustrates the percentage of assets holdings in HSAs and the fraction of the population with HSAs by health capital status. We see that the “sickest” population is less likely to have HSAs and if they do, the percentage of assets in HSAs is small. From panel 4 in figure 5 we already saw that the cohort around age 30 is the one with the lowest health capital. This is also the group that is least likely to have insurance (compare take up ratios in figure 3). This is a direct result of the income age profile. This age group has relatively low income and faces small health shocks. Therefore, this age group does not buy health insurance. The high price of health services without health insurance keeps them from investing in their health capital. However, this only holds for the lowest health capital group. The next highest group has already almost 50% of all assets invested in HSAs. Also, it turns out that the group with the smallest amount of health capital is already fully invested into Medicare as can be seen in panel 4.

Panel 4 depicts health insurance take-up ratios by health capital status. The most striking feature is that individuals with relatively low health states are buying the high deductible insurances. This does not confirm the findings in Zabinski et al. (1999). The difference between our result and theirs is largely explained by the health capital accumulation process. From panel 4 in figure 4 we have seen that middle aged workers have relatively low health capital. However, this is the cohort that is most likely to invest into HSAs because for them the tax free savings that comes with HSAs is attractive.

6.1.4 Sensitivity Analysis and General Equilibrium Effects

In order to study the role of general equilibrium effects, we fix the interest rate, wages, all insurance premiums, and the social security tax rate at their respective benchmark levels. This effectively turns off all feedback effects from factor markets and from insurance markets. Increases in savings do not affect the interest rate, decreases in aggregate effective human capital will not affect wages, and the increase in high deductible insurance will not affect the insurance premiums. We compare the results from this partial equilibrium analysis with HSAs in table 11 (column 3) with the results from the general equilibrium model with HSAs in regime [2]. We see that the effects are small but nevertheless lead to overstating the total health expenditures and the number of uninsured individuals. General equilibrium effects, in this sense, do increase the desired outcomes from HSAs, which are to decrease health expenditures and increase the number of individuals with health insurance.

Note that in partial equilibrium the number of insured individuals drops substantially from 80% to 73%. As more people buy the high deductible insurance (3.6% to 61%), the relative price of health services vs. consumption and savings increases and households spend less on their health. The direct consequence of this is that effective human capital decreases which decreases individual income via expression (5). Households adjust their consumption pattern to the drop in income and buy less insurance.

We further investigate the difference between partial equilibrium and general equilibrium effects by conducting sensitivity analysis on the health productivity parameter θ . If one believes the argument that households only forego unnecessary treatment after buying high deductible health insurances (e.g. Manning et al. (1987), or Matisson (2002)), then parameter θ in expression (2) should be close to zero ($\theta = 1$ is the benchmark economy). This effectively turns off the influence of health in the formation of human capital. Health then stops being an investment good and is only replenished for its consumption value. Health does not affect income or output anymore. We report the results of introducing HSAs for $\theta = 0, 0.3, 0.5, 0.6, 0.7, 0.8, 0.9$, and 1 in figure 7. We plot the change in the percentage of insured workers between the benchmark

economy and regime [2] with HSAs in panel one of figure 7. We call this the *extensive margin*. We see that as long as health capital is an investment good, the introduction of HSAs has a negative effect on the number of insured workers. HSAs increase the relative price of medical services to households. As households spend less on health services, their health capital deteriorates. Since health is productive, households lose income. This negative income effect dominates the decline in premiums. As a result, households forgo buying insurance. If, on the other hand, θ is small, health capital loses its investment good characteristic and turns into a consumption good. Households average health capital is still declining, but does not carry the large negative income effect. Since savings increase due to the tax deductibility of savings in HSAs, physical capital drives up production in the economy. Households experience a positive income effect and more workers buy insurance. There is no substantial difference between the partial equilibrium results and the general equilibrium results since the large income effects always dominate the price effects.

Panel two of figure 7 reports the effects on the *intensive margin*, that is the change in total health service expenditures due to the introduction of HSAs. When health is productive (θ close to one), negative income effects from lower health states add to the decrease in health service expenditures. The direct price effect from the high deductible insurance which makes health services relatively more expensive works in the same direction. Partial equilibrium results are again very close to the general equilibrium results. If, on the other hand, health becomes more of a consumption good, the negative income effects are diminished and households spend more on their health than in the benchmark economy. We now observe large differences between partial- and general equilibrium outcomes because price effects become the important distinguishing feature. Note also that only in the range of $\theta \in (0.5, 0.8)$ HSAs deliver on both goals, they increase the number of insured and decrease total health expenditures at the same time. If θ is outside of this range, only one of the two goals can be achieved.

The second parameter that we investigate is the annual contribution limit \bar{s}^m to HSAs given the benchmark health productivity ($\theta = 1$). There has been a lot of discussion whether HSAs could be misused for tax evasion. The policy maker has therefore introduced an annual savings limit, $\bar{s}^m = \$2,850$ for an individual ($\$5,650$ for a family). On the other hand, critics have questioned whether this savings limit is too low and therefore does not allow agents to save enough for their health. We repeat the experiment of regime [2] where the annual savings limit was fixed at $\bar{s}^m = \$2,850$, and calculate the steady state with HSAs with savings limits in the range between $\bar{s}^m \in [\$2,680, \$10,000]$. We plot the steady state results in figure 6. In addition we overlay the graph with the steady values from the benchmark economy, regime [1] where no HSAs were allowed. We see that our earlier results are fairly robust to changes in the annual savings limit. That is, aggregate health expenditures will decrease after introducing HSAs, whereas the number of uninsured still increases. However, the latter result can be overturned when the annual savings limit is pushed beyond $\$5,450$. In these cases HSAs increase the number of the insured population and decrease total health expenditures. If we further increase the annual savings limit beyond $\$8,000$ then the physical capital accumulation dominates the drop in human capital and output increases. This will make households richer and as a consequence they spend more on health care. Now HSAs lose their cost savings feature.

Given the initial health productivity ($\theta = 1$), an annual savings limit between $\$5,450$ and $\$8,000$ decreases total health expenditures and increases the number of insured individuals at the same time (see panel 1 and 2 in figure 6). On the other hand, panel 8 shows that residual government expenditure G drops off steadily as the annual savings limit increases. This is the effect from lost government revenue because more of the savings income becomes tax free. This is also the price the government has to pay in order to reduce total health expenditures. A policy recommendation would have to factor in how productive this government revenue is for

the economy as a whole. Since we do not model this aspect, we are not able to address this issue.

We conclude that HSAs can decrease total health expenditures in the economy. However, this effect is “paid for” with a larger number of uninsured individuals. Sensitivity analysis suggests that these results are robust to changes in the yearly contribution limits to HSAs. Only if the annual contribution limit is almost doubled, then the fraction of insured individuals stays above the fraction of insured in the benchmark economy.

6.2 Regime 3: Extended HSAs

Owcharenko (2006) reports that one particular reform suggested by the Affordability in the Individual Market Act (S.2554) would allow individuals to use HSA savings to pay for insurance premiums (retirees are already allowed to use HSAs to pay for Medicare Plan B,C and D premiums).

We implement this feature by changing the definition of net worth in the household budget constraint for workers (expression 4) to

$$NW_j = R^m a_{j-1}^m - o^W(m_j) - 1_{\{in_j=1\}}p_j - 1_{\{in_j=2\}}p'_j.$$

Column [3] in table 10 reports the steady state results for this regime. We see that by allowing workers to use their HSA funds to pay for health insurance premiums, the funds in the HSAs remain at a lower level of 0.6 compared to 0.62 in regime [2]. We observe the interesting effect that total health expenditures decrease by not quite as much as in regime [2] but that the number of insured stays higher. The reason is that more workers stay in the low deductible insurance, 19% compared to 11% in regime [2]. Because more of the high risk workers buy the insurance policies the average prices of both private health insurance premiums increase compared to regime [2]. The Medicare premium, on the other hand, decreases from 129 to 105.

6.3 Regime 4: Privatization of Medicare with HSAs

In regime [4] we replace Medicare with HSAs. Retirees are allowed to increase their holdings in HSAs. The total number of insured individuals increases by roughly 2%. At the same time total health expenditures decrease from 17.6% to 16.5% of GDP.

Eliminating Medicare increases total savings by almost 4%. Due to the fall in health expenditures, the health capital level in the economy is lower which effects the effective level of human capital that can be used in production. The next effect of the increase in physical capital and the decrease in human capital results in a negative output effect of roughly 1%.

A relatively large fraction of workers still buys the low deductible insurance (24%). Almost all of the retired workers buy the high deductible insurance (99%), since this insurance allows them to keep their HSAs. Also a large fraction of retirees use funds in HSAs for consumption purposes and therefore pay the 10% tax penalty. Since they are the ones with the higher risk of having bad health shocks, the average insurance paid for the high deductible plan increases by 9.6% compared to the benchmark regime. The Gini coefficient is slightly larger than in the benchmark economy.

We conclude that abolishing Medicare leads to higher insurance premiums for the high deductible insurance in the private markets but lowers total medical expenses. Output decreases due to the productivity loss from a lower aggregate health level. Aggregate welfare improves due to increases in savings and higher consumption levels.

6.4 Regime 5: Medicare for Workers

In this regime workers can choose between a low and high deductible private insurance. There are no HSAs available. In addition to the private insurance, agents can also decide to buy into Medicare during their working life. This puts the private plans in direct competition with the public health insurance plan.⁴⁹

Total health expenditures decrease slightly and the number of insured increases by 1%. We observe a shift from the low deductible health insurance into Medicare for workers. The fraction of workers with low deductible health insurance decreases from 73% to 59%. The fraction of high deductible insurance holders decreases by 1%. The fraction of workers holding Medicare is 15%. This influx of newly insured workers leads to a small increase in the Medicare premium (2.7%).

We again observe an increase in savings (3%) and a consequent increase in output (1%). The latter is possible, because human capital decreases only by 1.5% due to the small decrease in aggregate health expenditure. Government size, aggregate welfare, and the Gini coefficient are very similar to the benchmark economy.

We conclude that without an additional tax increase to finance a lowering of the Medicare premium, the increase in the number of insured workers is marginal.

6.5 Regime 6: No Insurances

In this regime, neither workers nor retirees are able to buy private health insurance, that is, we also abolish the Medicare program. The only public transfer programs available are the social insurance program T^{SI} and the pension program T^{Soc} . Column [6] in table 10 reports the steady state solution. Comparing the results with the benchmark economy we note the following differences.

Without insurance agents consume more of the consumption good and fewer health services. This has the consequence that they save less so that the capital output ratio decreases from 2.66 to 2.4. The accumulated health capital as fraction of GDP falls below the benchmark model, whereas consumption as fraction of GDP rises above the benchmark value. The low savings rate together with the lower health level, decreases output by 12%. The low level of health capital decreases aggregate welfare from -100 to -124 . Due to the lack of risk sharing the Gini coefficient rises above the Gini coefficients of all other regimes that have some kind of health insurance available.

In addition, the lack of insurance puts a lot of pressure on the low income population with severe health shocks. For this reason 1.62% of workers and 2.29% of retirees receive transfers from the social insurance program (e.g. foodstamps, Medicaid, etc.). We conclude that without any kind of health insurance steady state output decreases and welfare is lower than in all other regimes with some type of insurance. Health insurance increases output and welfare.

7 Conclusion

Our results indicate that HSAs can decrease total health expenditures by roughly 3% of GDP but can also increase the number of uninsured individuals by up to 5%. In addition, HSAs can decrease the effective price of the high deductible insurance. As more individuals switch from low to high deductible health insurances the effective price of health services relative to consumption goods increases. As a consequence, households buy fewer medical services. This results in a lower aggregate health capital level so that productive human capital also decreases. At the same time, savings increase due to the tax preferred treatment. However, the decrease in human capital dominates the increase in physical capital so that overall output decreases. These results depend

⁴⁹Former senator John Edwards has a similar plan in his health care reform package, see “Man of the Left”, in *The Economist*, July 19, 2007.

critically on the productivity of health capital and on the annual contribution limit to HSAs. We provide extensive sensitivity analysis to address both issues.

The effects on the wealth distribution are moderate but the effect on the government size are large. After the introduction of HSAs, government revenue drops so that government size (the residual tax revenue after deduction of transfers from the social insurance program) decreases significantly. This raises the question whether HSAs are the most efficient way to curb increases in health expenditures and insure more people as one may suspect that the lost government revenue leads to productivity losses in other sectors (e.g. less funding for public education, infrastructure, etc.).

How balanced is our assessment of the performance of HSAs? There are a few features that are omitted from the model that we think would weaken the case of HSAs. Among the most prominent features that we did not include are (i) adjustment costs to learn the new savings plan (e.g. in the model all consumers immediately understand all aspects of HSAs), (ii) no fixed fees of running insurance companies and HSAs⁵⁰, and (iii) no alternative savings vehicles are available in the benchmark model (e.g. absence of FSAs, HRAs, IRAs, and 401k's). Since our analysis concentrates on long run equilibria, adjustment costs play a minor role. However, it would be of interest to include fixed costs in running HSAs and alternative tax sheltered savings vehicles since both will affect the take up rate of high deductible insurances and the net increase in aggregate savings. Further extensions would encompass solutions for transition paths between the policy regimes in order to study welfare. Another interesting question concerns recent increases in health care productivity. A fully endogenized health care production sector would be able to address this issue. We leave this for future research.

References

2002 Annual Report of the Board of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Funds. 2002.

Anderson, Gerard. 2007. "From 'Soak The Rich' To 'Soak The Poor': Recent Trends In Hospital Pricing." *Health Affairs* 26(3):780–789.

Baicker, Katherine. 2006. "Improving Incentives in Health Care Spending." *Business Economics* 41(2):21–25.

URL: <http://www.springerlink.com/content/c03mw52w342v3172/>

Barr, Michael. 2001. "Medical Savings Accounts in Singapore: A Critical Inquiry." *Journal of Health Politics, Policy and Law* 26(4):709–726.

Barro, Robert J. and Chaipat Sahasakul. 1986. "Average Marginal Tax Rates on Social Security and the Individual Income Tax." *Journal of Business* 59:555–566.

Biggs, Andrew, Jeffrey Brown and Glenn Springstead. 2005. "Alternative Methods of Price Indexing Social Security: Implications for Benefits and System Financing." NBER Working Paper 11406.

Bloom, David E., David Canning and Jaypee Sevilla. 2004. "The Effect of Health on Economic Growth: A Production Function Approach." *World Development* 32(1):1–13.

⁵⁰GAO (2006) report that participants in their survey were initially unaware of a monthly \$3 administrative bank fee for maintaining the HSA and felt that it diminished any potential gains from interest earned on their HSA balance. If one included this feature in the model, the take-up rate of HSAs and high deductible insurance is likely to be lower.

- Brown, Paul. 2006. *Paying the Price: The High Cost of Prescription Drugs for Uninsured Californians*. CALPIRG Education Fund.
URL: <http://calpirg.org/reports/PayingthePriceCA.pdf>
- Budria-Rodriguez, Santiago, Javier Diaz-Gimenez, Vincenzo Quadrini and Jose-Victor Rios-Rull. 2002. "Updated Facts on the U.S. Distributions of Earnings, Income, and Wealth." *Federal Reserve Bank of Minneapolis Quarterly Review* 26(3):2–35.
- Buntin, Melinda B., Cheryl Damberg, Amelia Haviland, Kanika Kapur, Nicole Lurie, Roland McDevitt and Susan M. Marquis. 2006. "Consumer-Directed Health Care: Early Evidence About Effects on Cost and Quality." *Health Affairs* 25:516–530.
- Burman, Leonard E. and Linda J. Blumberg. 2003. "HSAs Won't Cure Medicare's Ills." Urban Institute.
URL: <http://www.urban.org/url.cfm?ID=1000578>
- Cardon, James H. and Mark H. Showalter. 2007. "Insurance Choice and Tax-Preferred Health Savings Accounts." *Journal of Health Economics* 26:373–399.
- Castaneda, Ana, Javier Diaz-Gimenez and Jose-Victor Rios-Rull. 2003. "Accounting for the U.S. Earnings and Wealth Inequality." *Journal of Political Economy* 111(4):818–857.
- Claxton, Gary, Jon Gabel, Isadora Gil, Jeremy Pickreign, Heidi Whitmore, Benjamin Finder, Bianca DiJulio and Samantha Hawkins. 2006. *Employer Health Benefits: 2006 Annual Survey*. Kaiser Family Foundation and Health Research and Educational Trust.
- Conesa, Juan C. and Dirk Krueger. 2005. "On the Optimal Progressivity of the Income Tax Code." NBER Working Papers 11044.
- Cutler, David and David Wise. 2003. "The U.S. Medical Care System for the Elderly." Harvard and NBER.
- Diaz-Gimenez, Javier, Vincenzo Quadrini and Jose-Victor Rios-Rull. 1997. "Dimensions of Inequality: Facts on the U.S. Distributions of Earnings, Income, and Wealth." *Federal Reserve Bank Minneapolis Quarterly Review* 21:3–21.
- Fernandez-Villaverde, Jesus and Dirk Krueger. 2004. "Consumption and Savings over the Life-Cycle: How Important are Consumer Durables?" 2004 Meeting Papers from Society for Economic Dynamics, No 357b.
- French, Eric and John B. Jones. 2004. "The Effects of Health Insurance and Self-Insurance on Retirement Behavior." Federal Reserve Bank of Chicago, Working Paper 2001-19.
- Fronstin, Paul and Sara R. Collins. 2006. "The 2 Annual EBRI/Commonwealth Fund Consumerism in Health Care Survey, 2006: Early Experience With High-Deductible and Consumer-Driven Health Plans." Employee Benefit Research Institute and The Commonwealth Fund, EBRI Issue Brief No. 300.
- GAO. 2006. "Consumer-Directed Health Plans: Early Enrollee Experiences with Health Savings Accounts and Eligible Health Plans."
- Gilleskie, Donna B. 1998. "A Dynamic Stochastic Model of Medical Care Use and Work Absence." *Econometrica* 66(1):1–45.
- Glied, Sherry A. and Dahlia K. Remler. 2005. "The Effect of Health Savings Accounts on Health Insurance Coverage." The Commonwealth Fund.

- Goodman, John C. 2004. "Statement on Health Savings Accounts." Testimony Before the U.S. Senate Special Committee on Aging, May 19, 2004.
- Gouveia, Miguel and Robert P. Strauss. 1994. "Effective Federal Individual Income Tax Functions: An Exploratory Empirical Analysis." *National Tax Journal* 47:317–339.
- Greene, Jessica, Judith Hibbard, Anna Dixon and Martin Tusler. 2006. "Which Consumers Are Ready for Consumer-Directed Health Plans?" *Journal of Consumer Policy* 29(3):247–262.
- Grossman, Michael. 1972. "On the Concept of Health Capital and the Demand for Health." *Journal of Political Economy* 80:223–255.
- Guner, Nezih, Remzi Kaygusuz and Gustavo Ventura. 2007. "Taxation, Aggregates and the Household." mimeo, The Pennsylvania State University.
- Heer, Burkhard and Alfred Maussner. 2005. *Dynamic General Equilibrium Modelling, Computational Methods and Applications*. Springer Verlag.
- Heffley, Dennis and Thomas J. Miceli. 1997. "The Economics of Incentive-Based Health Care Plans." Working Paper 1997-05, University of Connecticut.
- Hoffman, Catherine and Jennifer Tolbert. 2006. "Health Savings Accounts and High Deductible Health Plans: Are They An Option for Low-Income Families?" Kaiser Commission on Medicaid and the Uninsured.
- Hoffman, Catherine and Karyn Schwartz. 2006. "Who Are the Uninsured? A Consistent Profile Across National Surveys.".
- Hsiao, William C. 1995. "Medical Savings Accounts: Lessons from Singapore." *Health Affairs* 14(2):260–266.
- Hsiao, William C. 2001. "Behind the Ideology and Theory: What is the Empirical Evidence for Medical Savings Accounts?" *Journal of Health Politics, Policy and Law* 26(4):733–737.
- Hubbard, Glenn R., Jonathan Skinner and Stephen P. Zeldes. 1995. "Precautionary Saving and Social Insurance." *The Journal of Political Economy* 103(2):369–399.
- Huggett, Mark. 1996. "Wealth Distribution in Life-Cycle Economies." *Journal of Monetary Economics* 38:469–494.
- Imrohoroglu, Ayse, Selahattin Imrohoroglu and Douglas H. Joines. 1998. "The Effect of Tax-Favored Retirement Accounts on Capital Accumulation." *American Economic Review* 88(4):749–768.
- Income, Poverty, and Health Insurance Coverage in the United States: 2005*. 2006. Current Population Survey (CPS), U.S. Census Bureau.
URL: <http://www.census.gov/prod/2006pubs/p60-231.pdf>
- Jeske, Karsten and Sagiri Kitao. 2005. "Health Insurance and Tax Policy." *Federal Reserve Bank of Atlanta*.
- Jung, Juergen. 2006. "Estimating Markov Transition Probabilities between Health States in the HRS Dataset." Indiana University.
- Kaiser. 2000. "Prescription Drug Trends: A Chartbook." The Henry J. Kaiser Family Foundation.
URL: <http://www.kff.org/rxdrugs/3019-index.cfm>

- Keeler, Emmet B., Jesse D. Malkin, Dana P. Goldman and Joan L. Buchanan. 1996. "Can Medical Savings Accounts for the Nonelderly Reduce Health Care Costs?" *Journal of the American Medical Association* 275(21):1666–1671.
- Khwaja, Ahmed W. 2002. Health Insurance, Habits and Health Outcomes: Moral Hazard in a Dynamic Stochastic Model of Investment in Health. In *Proceedings of the 2002 North American Summer Meetings of the Econometric Society: Labor Economics and Applied Econometrics*, ed. David K. Levine and William Zame.
- Khwaja, Ahmed W. 2006. "A Life Cycle Analysis of the Effects of Medicare on Individual Health Incentives and Health Outcomes." *Journal of Econometrics* forthcoming.
- Kydland, Finn E. and Edward C. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50(6):1345–1370.
- Manning, Willard G., Joseph P. Newhouse, Naihua Duan, Emmett B. Keeler, Arleen Leibowitz and Susan M. Marquis. 1987. "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment." *American Economic Review* 77(3):251–277.
- Matisson, Shaun. 2002. "Medical Savings Accounts and Prescription Drugs: Evidence from South Africa." Report 254, Dallas: The National Center for Policy Analysis.
- Medicare and You*. 2007. U.S. Department of Health and Human Services, Centers for Medicare & Medicaid Services.
- Nadiri, M. Ishaq and Ingmar R. Prucha. 1996. "Estimation of the Depreciation Rate of Physical and R&D Capital in the U.S. Total Manufacturing Sector." *Economic Inquiry* 34(1):43–56.
- Nahata, Babu, Krzysztof Ostaszewski and Prasanna Sahoo. 2005. "Rising Health Care Expenditures: A Demand-Side Analysis." *Journal of Insurance Issues* 28(1):88–102.
- Owcharenko, Nina. 2006. "Building on the President's Health Care Agenda." Backgrounder No. 1934, The Heritage Foundation.
- Ozanna, Larry. 1996. "How will medical savings accounts affect medical spending?" *Inquiry* 33:225–236.
- Palumbo, Michael G. 1999. "Uncertain Medical Expenses and Precautionary Saving Near the End of the Life Cycle." *Review of Economic Studies* 66(2):395–421.
- Park, Edwin, Robert Greenstein and Joel Friedman. 2006. "Last-Minute Addition to Tax Package Would Make Health Savings Accounts More Attractive as Tax Shelters for High-Income Individuals." Center on Budget and Policy Priorities.
- Pauly, Mark V. and Bradley J. Herring. 2000. "An Efficient Employer Strategy for Dealing with Adverse Selection in Multiple-Plan Offerings: An MSA Example." *Journal of Health Economics* 19:513–528.
- Playing Fair, State Action to Lower Prescription Drug Prices*. 2000. Center for Policy Alternatives.
- Poterba, James M., Steven F. Venti and David A. Wise. 1995. "Do 401(k) Contributions Crowd Out Other Personal Saving?" *Journal of Public Economics* 58(1):1–32.

- Prescription Drug Coverage, Spending, Utilization, and Prices: Report to the President.* 2000. U.S. Department of Health and Human Services.
URL: <http://aspe.hhs.gov/health/reports/drugstudy/>
- Remler, Dahlia, K. and Sherry A. Glied. 2006. "How Much More Cost Sharing Will Health Savings Accounts Bring?" *Health Affairs* 25(4):1070–1078.
- Rust, John and Christopher Phelan. 1997. "How Social Security and Medicare Affect Retirement Behavior in a World of Incomplete Markets." *Econometrica* 65(4):781–832.
- Schultz, Paul T. 2002. "Wage Gains Associated with Height as a Form of Health Human Capital." *American Economic Review* 92(2):349–353.
- Six, Sarah. 2003. "Update on the Older Worker: 2002." *Data Digest* 88, AARP.
- Smyth, Seamus J. 2005. "A Bancing Act: Optimal Nonlinear Taxation in Overlapping Generations Models." Harvard University, Department of Economics.
- Social Security Update 2007.* 2007. SSA Publication No. 05-10003.
- Stephenson, Frank E. 1998. "Average Marginal Tax Rates Revisited." *Journal of Monetary Economics* 41:389–409.
- Suen, Richard M. H. 2006. "Technological Advance and the Growth in Health Care Spending." *Economie D'Avant Garde*, Research Report No. 13. University of Rochester.
- Tauchen, George. 1986. "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions." *Economics Letters* 20:177–181.
- The 2002 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Disability Insurance Trust Funds.* 2002. Social Security Administration.
- The Cost and Benefit of Individual Health Insurance Plans.* 2005. eHealthInsurance.
URL: www.ehealthinsurance.com/content/ReportNew/110905CandBReportFinal.pdf
- Watanabe, Masahito. 2005. "When Do Health Savings Accounts Decrease Health Care Costs?"
- Whitehouse, Edward. 2003. "The Value of Pension Entitlements: A Model of Nine OECD Countries." *OECD Social Employment and Migration Working Papers* (9).
- Yu, William W. and Trena M. Ezzati-Rice. 2005. "Concentration of Health Care Expenditures in the U.S. Civilian Noninstitutionalized Population." *MEPS Statistical Brief* (81).
- Zabinski, Daniel, Thomas M. Selden, John F. Moeller and Jessica S. Banthin. 1999. "Medical Savings Accounts: Microsimulation Results from a Model with Adverse Selection." *Journal of Health Economics* 18:195–218.

8 Appendix A

8.1 Tables

Parameters:		Explanation/Source:	Free Paras
- Periods working	$J_1 = 5$		
- Periods retired	$J_2 = 3$		
- Population growth rate	$n = 2.5\%$	- to match > 65 at 12.4% of population ($n = 1.2\%$ in U.S. Census 2006)	
- Years modeled	$years = 72$	from age 20 to 92	
- Relative risk aversion	$\sigma = 1.5$	to match $\frac{K}{Y}$ and R	1
- Preference on consumption	$\eta_j = \left\{ \begin{array}{l} 0.65, 0.95, 0.96, 0.96, \\ 0.95, 0.85, 0.80, 0.80 \end{array} \right\}$	to match $\frac{p \times M}{Y}$	8
- Discount factor	$\beta = 1.025^{(72/8)}$	to match $\frac{K}{Y}$ and R	1
- Health production productivity	$\phi_j = \left\{ \begin{array}{l} 1.5, 1.5, 1.5, 1.5, \\ 1.5, 1.5, 1.65, 1.65 \end{array} \right\}$	to match $\frac{p \times M}{Y}$	8
- Production parameter of health	$\xi = 0.35$ $\delta_{h_{\min}} = 1 - 0.80^{(years/J)}$ $= 0.8658$	to match $\frac{p \times M}{Y}$	1
- Health depreciation	$\delta_{h_{\max}} = 1 - 0.87^{(years/gJ)}$ $= 0.7145$	to match $\frac{p \times M}{Y}$	2
- Human capital production	$\chi = 0.85$	to match income distribution	1
- Health productivity	$\theta = 1$	used for sensitivity analysis	1
- Human capital profile	$\{\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2\} = \{8.12, 0.14, -0.0015\}$	U.S. Census 2005	
- Insurance premium growth	$\{\hat{x}_0, \hat{x}_1, \hat{x}_2\} = \{0.7781, 0.0036, 0.0007\}$	www.eHealthInsurance.com	
- Price for medical care for insured	$p_{m,Ins} = 1.3891$	U.S. Census 2004	
- Price for medical care for uninsured	$p_{m,nIns} = 2.2226$	U.S. Census 2004	
- Capital share in production	$\alpha = 0.33$	standard value	
- Capital depreciation	$\delta = 1 - 0.9^{(years/J)} = 0.6126$	Kydland and Prescott (1982) Nadiri and Prucha (1996)	
- Total factor productivity	$A = 4$	normalization	
- Health Shocks	see table 3		20
- Asset grid	$a_{Grid} = [0, \dots, 24]_{1 \times 80}$		
- HSA asset grid	$a_{Grid}^m = [0, \dots, 8]_{1 \times 14}$		
- Health grid	$h_{jGrid} = [0.01, \dots, 6]_{1 \times 16}$		
- State space	1, 881, 600		

Table 1: Parameters for Calibration

Policy Parameters:		Explanation/Source:	Nr. of free parameters
- Pension replacement rate	$\Psi = 0.21$	to match $\tau^{soc} = 10\%$ - By law this is 2.92%. Need to pick higher rate,	1
- Payroll tax Medicare:	$\tau^{Med} = 4\%$	so that workers in last period buy Medicare Plan B, and $p^{Med} < p$.	1
- Low deductible	$\rho = 0.15$	- to match percentage of insured to be close to 80%	1
- High deductible	$\rho' = 1.15$	- to match $\frac{\rho}{\rho'} = 0.13$ according to Fronstin and Collins (2006)	
- Medicare deductible	$\rho^{Med} = 0.46$	- to match $\frac{\rho}{\rho^{Med}} = 0.28$ according to Fronstin and Collins (2006) and the U.S. Department of Health	
- Coinsurance rate, low deductible	$\gamma = 0.25$	0.25 in Suen (2006)	1
- Coinsurance rate, high deductible	$\gamma' = 0.20$	to match insurance take-up rate	
- Coinsurance rate, Medicare	$\gamma^{Med} = 0.25$	- Center for Medicare and Medicaid Services (2005)	
- Saving limit markup	$v = 0.2232$	- Revenue procedure 2006-53 and Fronstin and Collins (2006)	
- Maximum contribution to HSAs	$\bar{s}^m = \$2,850$	- Revenue procedure 2006-53 and Fronstin and Collins (2006)	
-Total number of free parameters incl. table 1			47

Table 2: Policy Parameters for Calibration

	Shock 1	Shock 2	Shock 3	Shock 4	Shock 5
Age					
20-28:	0.00	0.00	-0.02	-0.04	-0.10
29-38:	0.00	0.00	-0.02	-0.34	-1.60
39-47:	0.00	0.00	-0.02	-0.04	-3.25
48-56:	0.00	0.00	-0.02	-0.04	-4.20
57-65:	0.00	0.00	-0.02	-0.14	-4.83
66-74:	0.00	-0.05	-0.20	-0.40	-5.00
75-83:	0.00	-0.05	-0.20	-0.40	-5.00
84-92:	0.00	-0.05	-0.20	-0.40	-6.00

Table 3: Health shocks per age group. Health shocks account for 20 separate free parameters. We use identification restrictions on some of the shocks. Shocks 1,2, and 3 do not change over age for all workers. In addition, Shocks 1,2, 3, and 4 also do not change over age for all retirees.

Yearly Income Level:	Marginal Income Tax Rate: τ
up to \$7,150	10%
\$7,151 – \$29,050	15%
\$29,051 – \$70,350	25%
\$70,351 – \$146,750	28%
\$146,751 – \$319,100	33%
over \$319,100	35%

Table 4: Source: <http://taxes.yahoo.com/rates.html>

Number and Percent of People by Health Insurance Coverage Type, 2000 to 2004				
Year	Uninsured		Medicaid/SCHIP	Job-Based Insurance
	Number (millions)	Percent	Percent	Percent
2000	39.8	14.2%	10.6%	63.6%
2001	41.2	14.6%	11.2%	62.6%
2002	43.6	15.2%	11.6%	61.3%
2003	45.0	15.6%	12.4%	60.6%
2004	45.8	15.7%	12.9%	59.8%

Table 5: Source: U.S. Census Bureau 2004

Deductible Levels for Policies Purchases by eHealthInsurance		
	Percentage of Policies Purchased	
Deductible	Individuals	Families
\$500 or less	39.1%	24.9%
\$501 – \$999	4.1%	4.5%
\$1,000 – \$1,500	28.0%	31.4%
\$1,501 – \$1,999	0.7%	0.0%
\$2,000 – \$3,000	18.4%	22.0%
over \$3,000	9.7%	17.25
Total	100%	100%

Table 6: Source: eHealthInsurance 2004 at [www.ehealthinsurance.com/content/ Report-New/110905CandBReportFinal.pdf](http://www.ehealthinsurance.com/content/Report-New/110905CandBReportFinal.pdf)

Total Health Care Expenditure:		Data (in %)	Model (in %)
Percent of Total Population			
1%		22.000	20.609
5%		49.000	34.092
10%		64.000	45.499
50%		97.000	92.493

Table 7: Distribution of Health Expenditures in the U.S. Economy. Data is from MEPS 2002 as summarized in Yu and Ezzati-Rice (2005).

	Gini	1. Quintile	2. Quintile	3. Quintile	4. Quintile	5. Quintile
Wealth:						
Data 1992	0.780	-0.390	1.740	5.720	13.430	79.490
Data 1998	0.803	-0.300	1.300	5.000	12.200	81.700
Model	0.728	0.000	0.000	0.810	17.108	82.082
Income:						
Data 1998	0.553	2.400	7.200	12.500	20.000	58.000
Model	0.430	3.923	8.094	19.089	29.044	39.850

Table 8: Distribution of Wealth in the U.S. Economy (%). 1992 Data from Diaz-Gimenez, Quadrini and Rios-Rull (1997) and 1998 data from Budria-Rodriguez et al. (2002).

Parameters	Model	Data	Source	Nr. of Moments
- Medical expenses per GDP: $\frac{pm \times M}{Y}$	17.6%	16%	Baicker (2006)	1
- Fraction of insured workers: (private insurance)	53%	- 86.1% of <65: private 69% (employment based 59.8%) public: 19%	- Meps 2005 and U.S. Census Bureau 2006	1
- Fraction of insured workers: (private insurance, not counting uninsured in first generation)	76.55%	- 86.1% of <65: private 69% (employment based 59.8%) public: 19%	- Meps 2005 and U.S. Census Bureau 2006	1
- Fraction of insured retirees:	99.7%	99.7%	MEPS 2005	1
- Low deductible insurance (of all insured)	95.4%	90%	Fronstin and Collins (2006)	1
- High deductible insurance (of all insured)	4.6%	10%	Fronstin and Collins (2006)	1
- Ratio of low vs. high deductible premium: $\sum_j \mu_j p_j / \sum_j \mu_j p'_j$	0.72	0.6 to 1.2	- Fronstin and Collins (2006) and Claxton et al. (2006)	1
- Ratio of low deductible vs. Medicare premium: $\frac{\sum_j \mu_j p_j}{\sum_j \mu_j p_j^{Med}}$	1.22	0.13 to 3.86	- Fronstin and Collins (2006), Claxton et al. (2006), and U.S. Department of Health 2006	1
- Ratio of average low deductible premium vs. median income: $\frac{\sum_j \mu_j p_j}{med(income)}$	0.12	0.07 to 0.23	- Fronstin and Collins (2006), Claxton et al. (2006) and U.S. Census 2005	1
Ratio deductible vs. average premium				
- Low deductible plan: $\frac{\rho}{\sum_j \mu_j p_j}$	0.17	0.07 to 0.23	- Fronstin and Collins (2006), Claxton et al. (2006), and U.S. Department of Health 2006	1
- Highdeductible plan: $\frac{\rho'}{\sum_j \mu_j p'_j}$	0.95	0.66 to 1.15	- same source as above,	1
- Medicare: $\frac{\rho^{Med}}{\sum_j \mu_j p_j^{med}}$	0.74	1	U.S. Department of Health 2006	1
Ratio deductible vs. median income				
- Low deductible plan: $\frac{\rho}{med(income)}$	0.02	0.017	- Fronstin and Collins (2006) and U.S. Census 2005	1
- Highdeductible plan: $\frac{\rho'}{med(income)}$	0.16	0.13	- Fronstin and Collins (2006) and U.S. Census 2005	1
- Medicare: $\frac{\rho^{Med}}{med(income)}$	0.07	0.06	U.S. Department of Health 2006 and U.S. Census 2005	1
- Capital output ratio: K/Y	2.7	3	NIPA	1
- Interest rate: R	4.6%	4%	NIPA	1
- Government consumption: G/Y	20.3%	20.2%	Castaneda et al. (2003)	1
- Size of Social Security: SocSec/Y	6.3%	5%	Social Security Administration 2002	1
- Size of Medicare: Medicare/Y	4.4%	2.5%	U.S. Department of Health 2002	1
- Fraction over 65	13.97%	12.4%	U.S. Census 2005	1
- Payroll tax Social Security: τ^{Soc}	10.2%	6%-10%	IRS ⁵¹ and	1
- Average marginal income tax: $\bar{\tau}$	11%	21.5% to 32.1%	- Stephenson (1998) and Barro and Sahasakul (1986)	1
- Gini Wealth	0.73	0.8	Budria-Rodriguez et al. (2002)	1
- Gini Income	0.43	0.55	Budria-Rodriguez et al. (2002)	1
- Income and savings profile		see figure 2		13
- Insurance take-up ratios		see figure 2		10
Total number of Moments				47

Table 9: Data vs. Model

	[1 Benchmark]	[2]	[3]	[4]	[5]	[6]
Health Expenditures (in % of GDP):	17.642	14.367	15.105	16.500	17.413	11.024
All Insured (in %):	80.136	75.033	77.068	81.949	81.503	0.000
Output Y :	100.000	97.017	96.712	99.099	101.072	87.993
Capital K :	100.000	101.172	98.655	103.991	102.964	79.734
Health Capital H :	100.000	84.521	86.039	89.963	98.499	66.381
K/Y :	2.662	2.776	2.715	2.793	2.712	2.412
H/Y :	5.280	4.600	4.698	4.794	5.146	3.984
Assets a :	1.258	0.683	0.974	0.651	1.299	0.986
Assets in HSA a^m :	0.000	0.622	0.258	0.669	0.000	0.000
Consumption C :	100.000	107.236	107.636	104.797	101.370	119.616
C/Y :	0.319	0.353	0.356	0.338	0.320	0.434
Interest Rate $R = 1 + r$:	1.046	1.043	1.045	1.042	1.045	1.055
Social Security Tax τ^{Soc} :	0.102	0.108	0.108	0.109	0.102	0.105
Avge. Marg. Income Tax: τ :	0.109	0.099	0.099	0.100	0.110	0.105
% of Workers paying Penalty:	0.000	0.000	0.000	0.000	0.000	0.000
% of Retirees paying Penalty:	0.000	52.414	11.426	33.934	0.000	0.000
T^{SI} Worker in %:	0.319	0.445	0.394	0.314	9.178	1.623
T^{SI} Retiree (in %):	0.022	0.019	0.019	1.074	0.021	2.290
Insured Workers Low (in %):	72.955	11.107	18.808	23.952	59.309	0.000
Insured Workers High(in %):	3.594	59.387	54.092	54.775	2.644	0.000
Insured Workers (in %):	76.549	70.494	72.900	78.728	77.246	0.000
Insured Retirees Low (in %):	0.000	0.000	0.000	0.438	0.000	0.000
InsuredRetirees High (in %):	0.000	0.000	0.000	99.089	0.000	0.000
Insured Retirees (in %):	99.714	99.805	99.810	99.527	99.752	0.000
All Insured(in %):	80.136	75.033	77.068	81.949	81.503	0.000
Insurance Premium p^{Low} :	0.597	0.597	0.608	0.606	0.608	0.000
Insurance Premium p^{High} :	0.627	0.634	0.642	0.590	0.628	0.000
Average Insurance Premium p^{Low} :	100.000	73.935	77.743	78.218	90.020	0.000
Average Insurance Premium p^{High} :	100.000	87.388	90.488	109.612	89.919	0.000
Medicare Premium p^{Med} :	100.000	128.750	105.086	0.000	102.751	0.000
Government Size G/Y (in %):	20.277	15.404	16.033	16.470	20.371	11.458
Aggregate Welfare:	-100.000	-96.776	-96.658	-96.815	-99.475	-124.108
Gini Coefficient:	0.728	0.713	0.721	0.732	0.728	0.748

Table 10: Six Regimes: [1 *Benchmark*] two insurance types without HSAs, [2] two insurance types with HSAs, [3] HSAs funds can be used to pay health care premiums, [4] HSAs without Medicare, [5] workers can buy into Medicare, and [6] no insurance. In regime [1], [2], [3], [4], and [5] agents can choose between low and high deductible insurances. In regime [1], [5] and [6] HSAs are not available. In regime [2], [3] and [4] the high deductible insurance can be linked to an HSA.

	[1 Benchmark]	[2]	no G.E. Effects
Health Expenditures (in % of GDP):	17.642	14.367	14.011
All Insured (in %):	80.136	75.033	73.383
Output Y :	100.000	97.017	100.000
Capital K :	100.000	101.172	102.931
Health Capital H :	100.000	84.521	83.688
K/Y :	2.662	2.776	2.740
H/Y :	5.280	4.600	4.419
Assets a :	1.258	0.683	0.669
Assets in HSA a^m :	0.000	0.622	0.644
Consumption C :	100.000	107.236	110.407
C/Y :	0.319	0.353	0.353
Interest Rate $R = 1 + r$:	1.046	1.043	1.046
Social Security Tax τ^{Soc} :	0.102	0.108	0.102
Avge. Marg. Income Tax: τ :	0.109	0.099	0.098
% of Workers paying Penalty:	0.000	0.000	0.000
% of Retirees paying Penalty:	0.000	52.414	77.615
T^{SI} Worker (in %):	0.319	0.445	0.485
T^{SI} Retiree (in %):	0.022	0.019	0.018
Insured Workers Low (in %):	72.955	11.107	7.676
Insured Workers High(in %):	3.594	59.387	60.863
Insured Workers (in %):	76.549	70.494	68.538
Insured Retirees Low(in %):	0.000	0.000	0.000
InsuredRetirees High(in %):	0.000	0.000	0.000
Insured Retirees (in %):	99.714	99.805	99.821
All Insured (in %):	80.136	75.033	73.383
Insurance Premium p^{Low} :	0.597	0.597	0.597
Insurance Premium p^{High} :	0.627	0.634	0.627
Average Insurance Premium p^{Low} :	100.000	73.935	72.790
Average Insurance Premium p^{High} :	100.000	87.388	85.984
Medicare Premium p^{Med} :	100.000	128.750	99.999
Government Size G/Y (in %):	20.277	15.404	14.916
Aggregate Welfare:	-100.000	-96.776	-95.432
Gini Coefficient:	0.728	0.713	0.709

Table 11: Three Regimes: [1 Benchmark] two insurance types without HSAs, [2] two insurance types with HSAs, and [no G.E. Effects] has two insurance types with HSAs where we fixed prices w , R , p , p' , p^{Med} , and τ^{Soc} to benchmark levels.

8.2 Figures

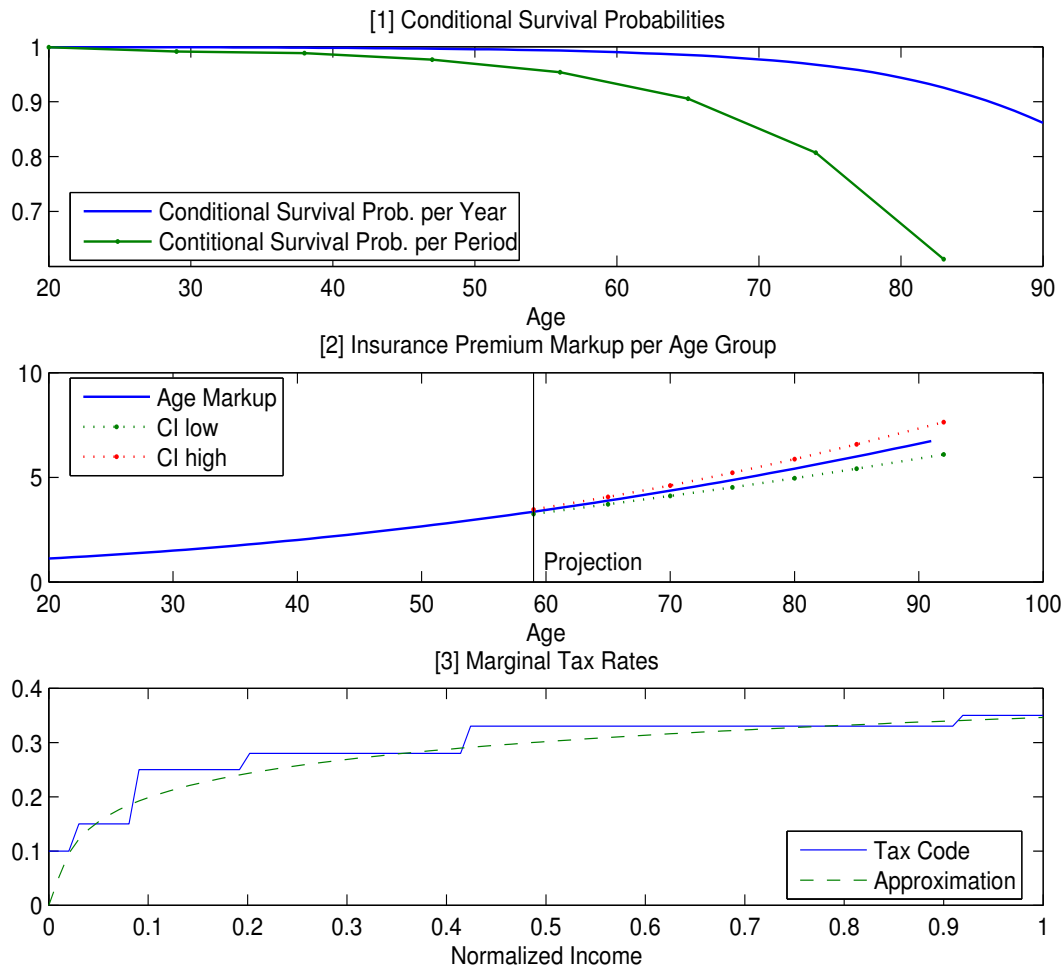


Figure 1: Panel (1): Conditional Survival Probabilities from U.S. Life-Tables 2003. Panel (2): Premium Markup per Age Group. Source: 2005 Data from www.ehealthinsurance.com. Panel (3): Income Tax Function Approximation.

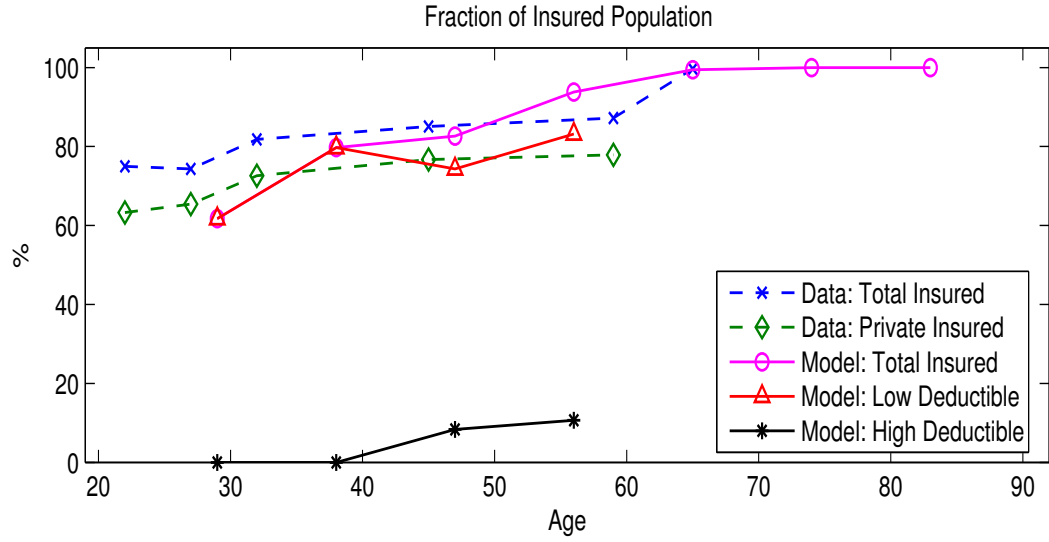


Figure 2: [1] Benchmark Model: 2 Insurances and no HSAs. Panel (1): Health Insurance Coverage of the Civilian Noninstitutionalized Population in the U.S. 2005. Source: MEPS 2005. Panel (2): Human Capital Profile and Income Data per Age Cohort. Source: U.S. Census 2006, CPS. Panel (3): Wealth Age Distribution. Source: Data U.S. Census 2000.

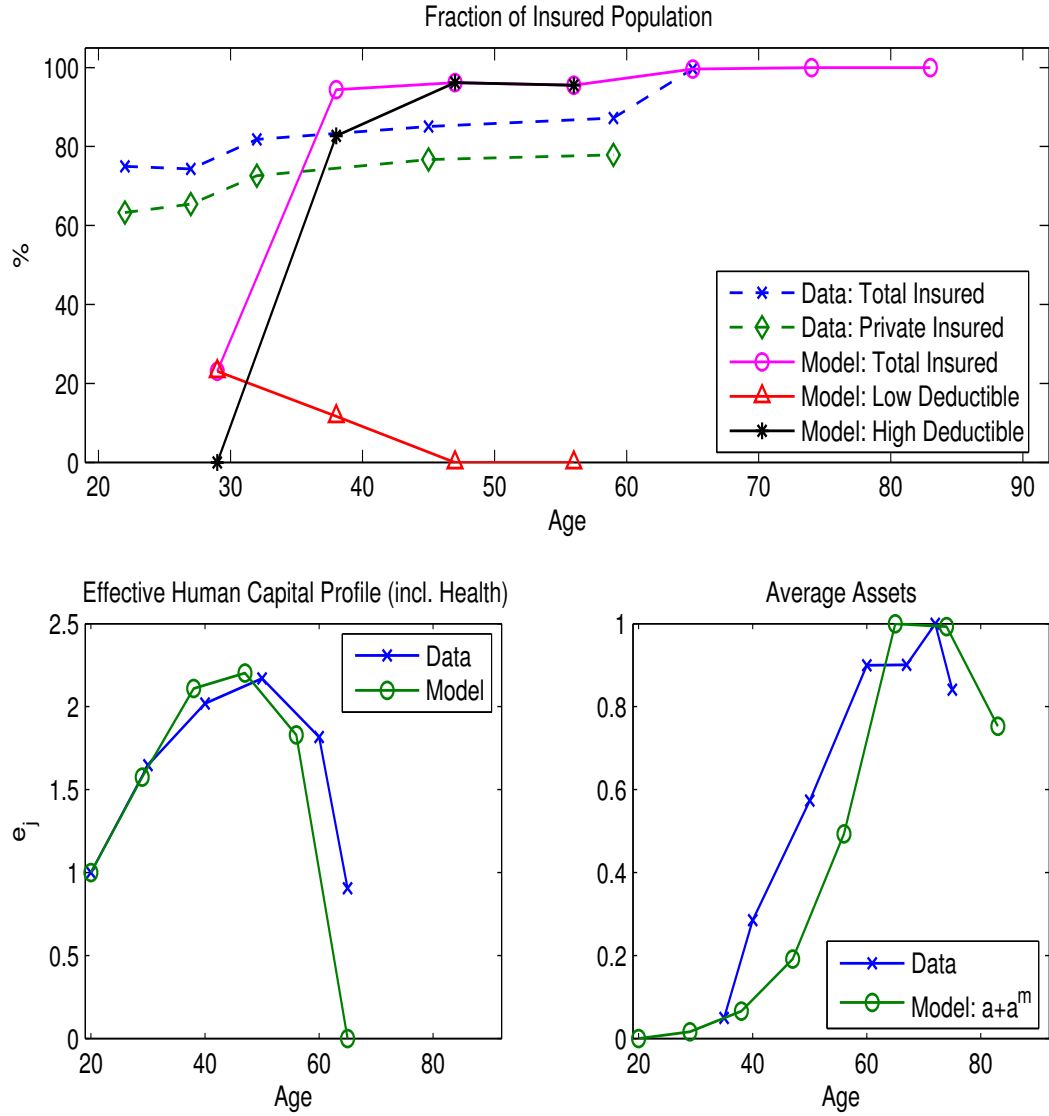


Figure 3: Regime [2]: 2 Insurances and HSAs. Panel (1): Health Insurance Coverage of the Civilian Noninstitutionalized Population in the U.S. 2005. Source: MEPS 2005. Panel (2): Human Capital Profile and Income Data per Age Cohort. Source: U.S. Census 2006, CPS. Panel (3): Wealth Age Distribution. Source: Data U.S. Census 2000.

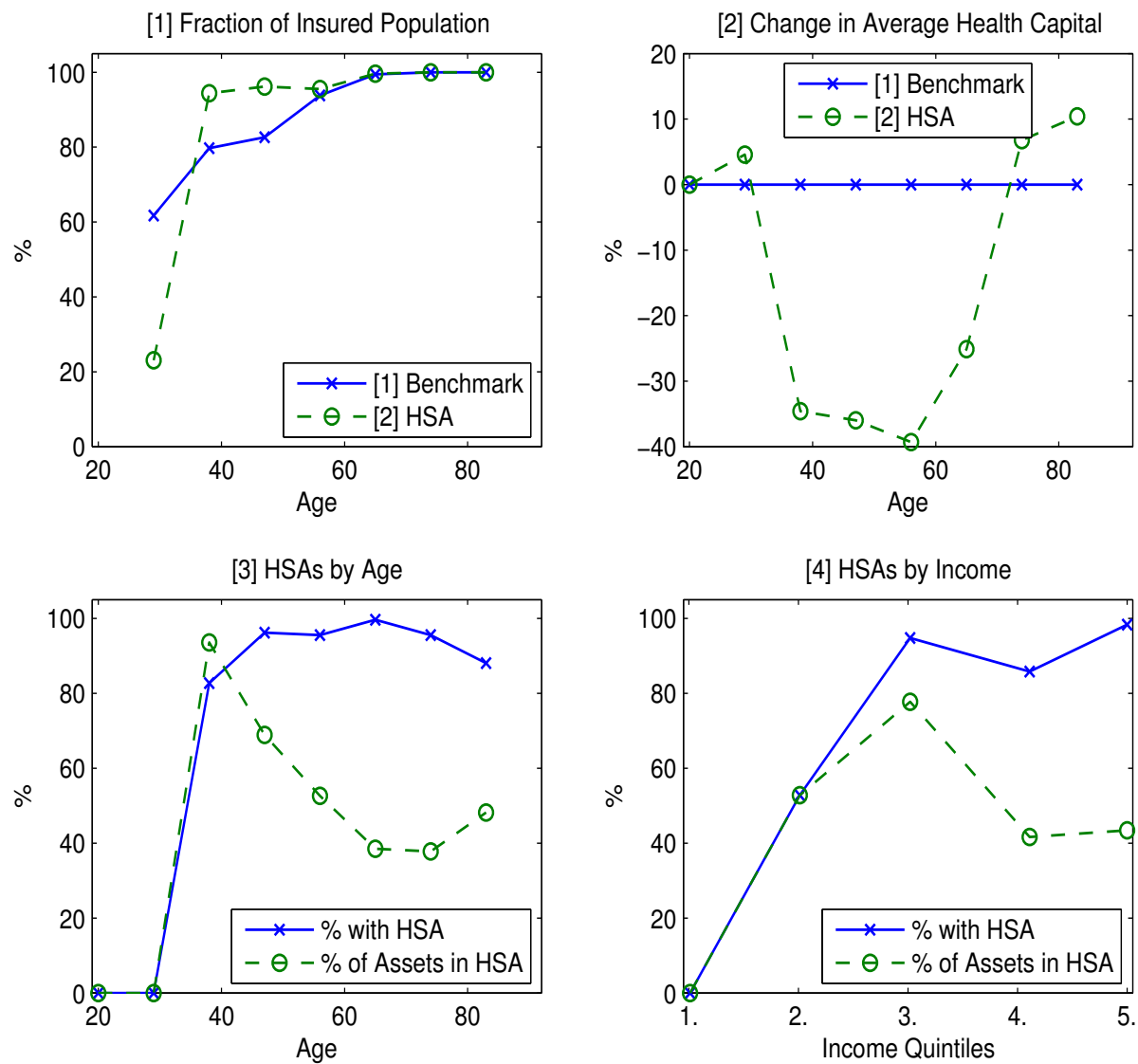


Figure 4: Fraction of insured workers before and after the policy experiment of introducing HSAs. Panel (1): Percentage of insured workers per age group. Panel (2): Percentage of insured workers per income quintile. Panel (3): Percentage of insured workers per health capital state. Panel (4): Average health capital per age group.

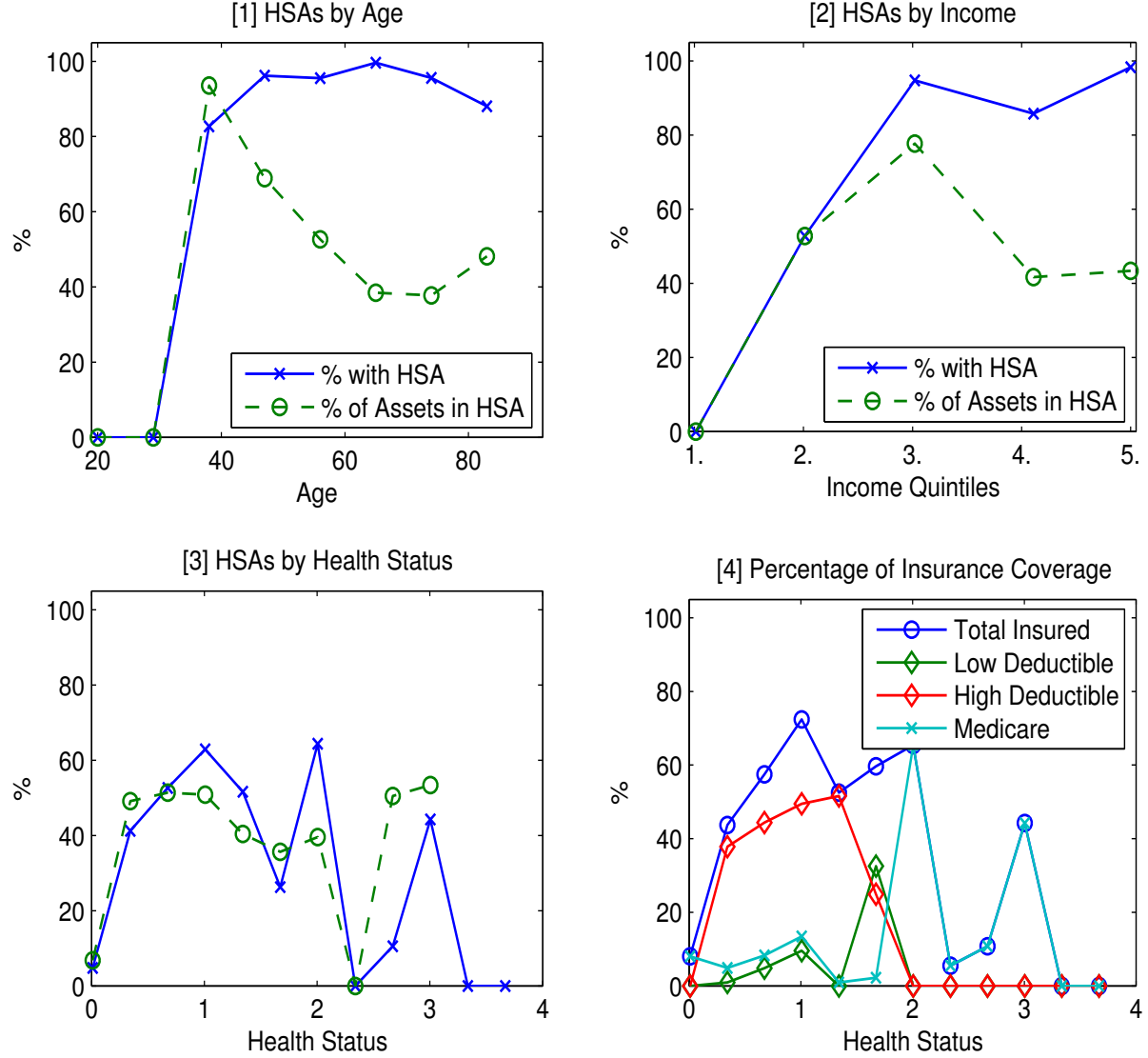


Figure 5: Panel (1): Percentage of assets held in the form of funds in HSAs by age group and percentage of the population with HSAs per age group. Panel (2): Percentage of assets held in the form of funds in HSAs by income quintile and percentage of the population with HSAs by income quintile. Panel (3): Percent of assets in HSAs by health state and percent of the population with HSAs by health state. Panel (4): Percentage of insurance coverage type by health state. All results are for regime [2], the model with two insurance types and HSAs.

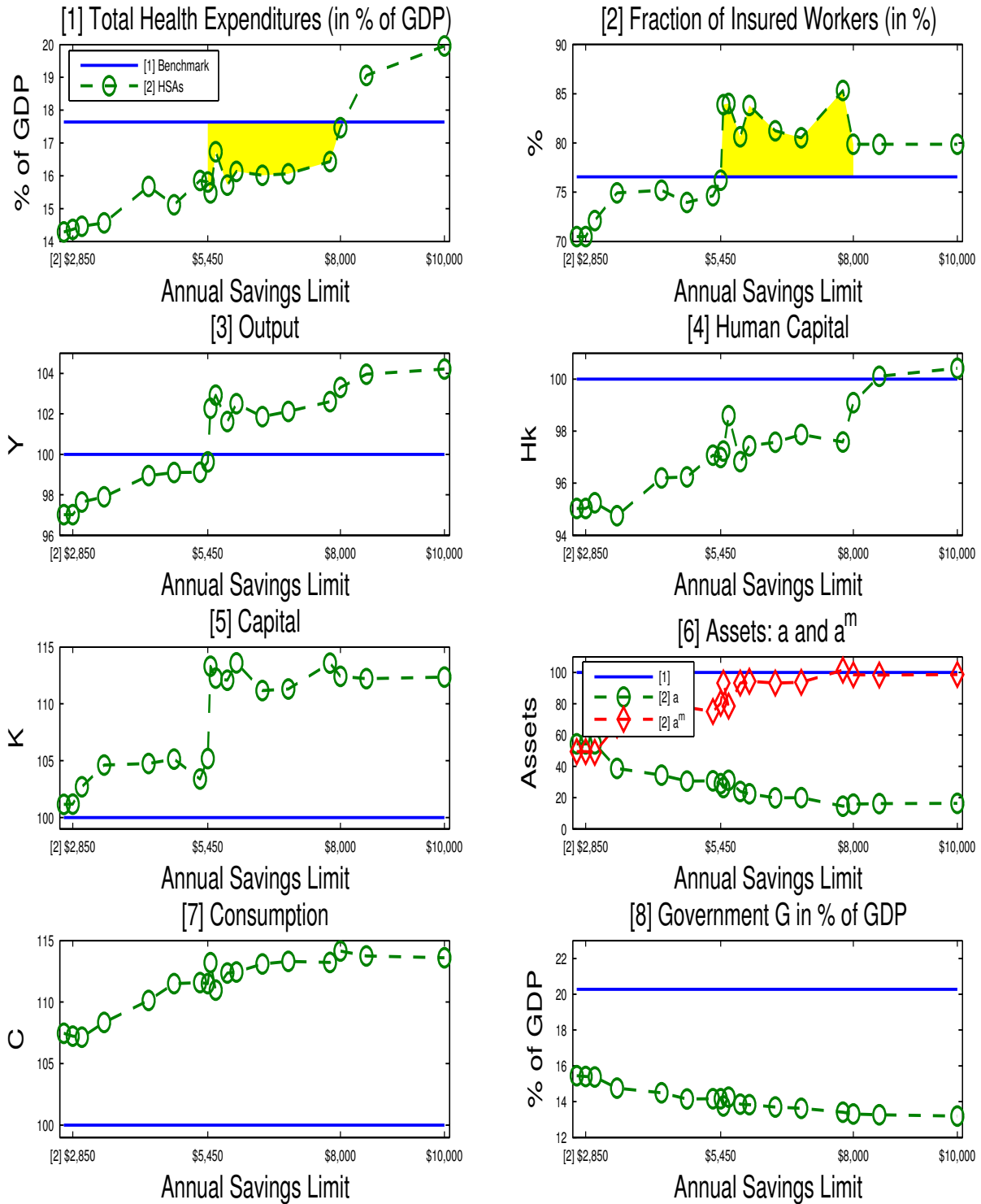


Figure 6: Sensitivity Analysis. We vary the annual contribution limit to HSAs, according to $\bar{a}^m = \{\$2,050; \$2,680; \$2,850; \$3,025; \$3,455; \$4,310; \$5,825\}$ and compare the results to the benchmark economy [1 *Benchmark*] with no HSAs.

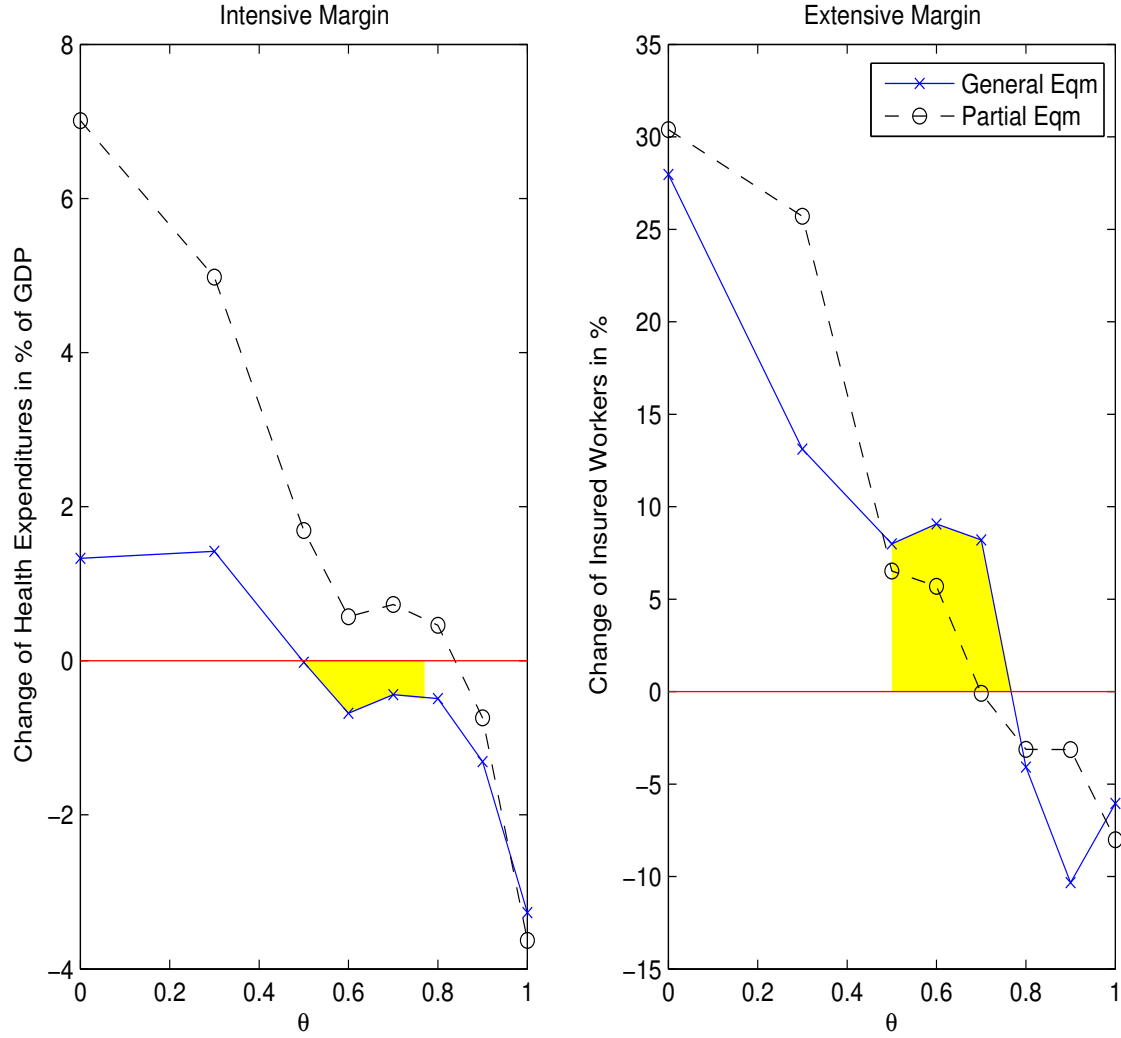


Figure 7: Sensitivity Analysis. We vary the health productivity parameter θ according to $\theta = \{0, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ and compare the General Equilibrium with HSAs result and the Partial Equilibrium with HSAs result to the benchmark economy [1 *Benchmark*] with no HSAs.

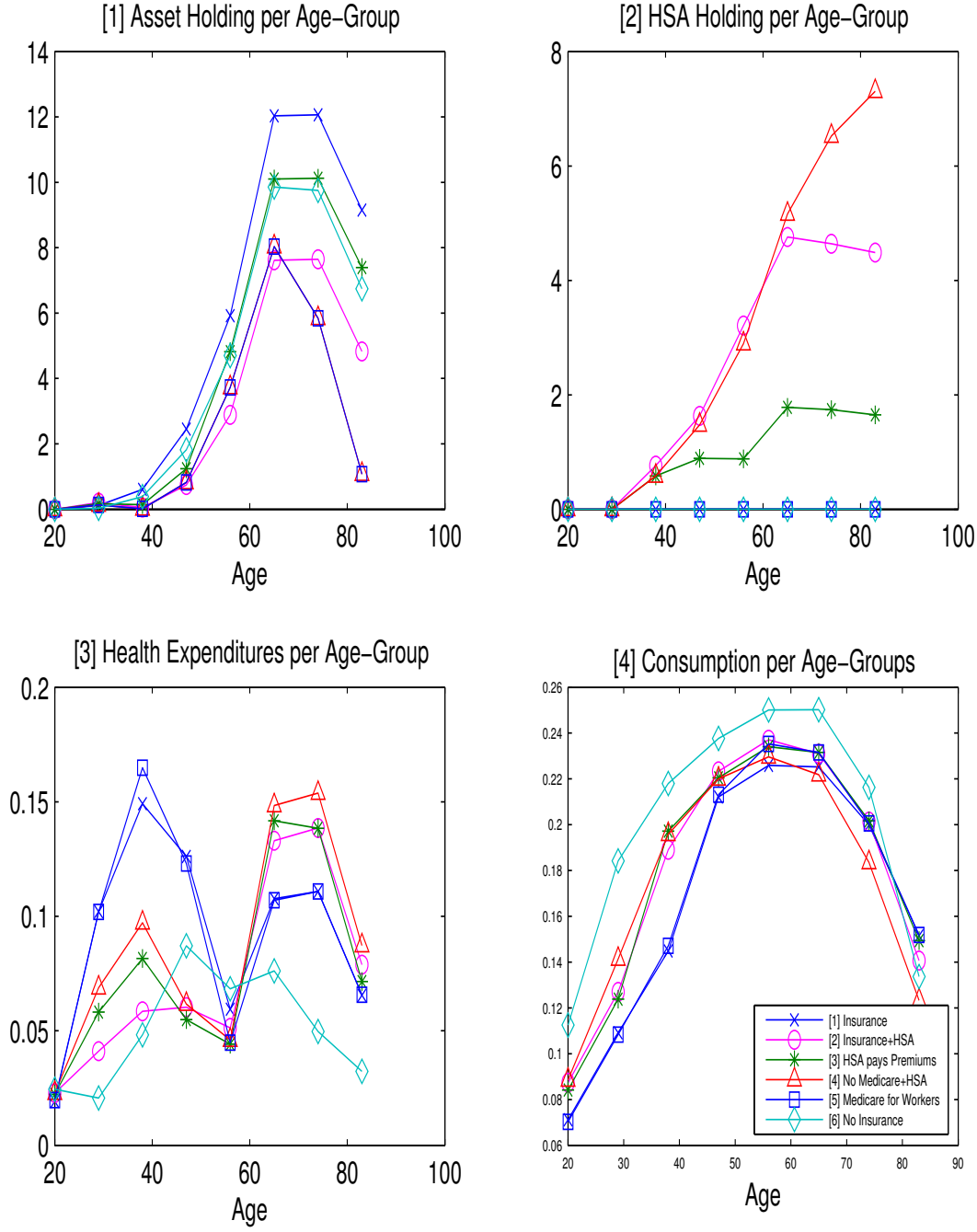


Figure 8: Aggregate Variables for Six Regimes. Panel (1) aggregate asset holdings, panel (2) aggregate holdings in HSAs, panel (3) aggregate medical expenditures, and panel (4) aggregate consumption. The regimes are: [1 *Benchmark*] two insurance types without HSAs, [2] two insurance types with HSAs, [3] HSAs funds can be used to pay health care premiums, [4] HSAs without Medicare, [5] workers can buy into Medicare, and [6] no insurance.